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THE FEBRUARY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

FEBRUARY, 1930

KIM KURMAH, OR, WHAT ARE WE ABOUT?[1]

By Professor G. H. PARKER

HARVARD UNIVERSITY

WERE I to address you in the spirit of the "Systema Naturae" of 1758, I might say to each one of you, "Homo sapiens, subspecies naturae investigator americanus, race demonicensis." I would thereby recall to you through the specific part of your name the compliment that old father Linnaeus slyly passed to himself and to us all in designating us men of wisdom. Nor do I believe that he would object to my addition to his terminology, for are we not American naturalists, and residents, at least for the time being, of Des Moines? To this new-world domicile of the monk, for so I understand the ancient meaning of its name, we have come to partake of its refreshment, physical and intellectual. The dictionary tells us that the moines or monks are a company of men vowed to separation from the world, to poverty, to celibacy and to a religious life. Have we found them such? Yes and no. I shall not attempt to enlarge upon the fact that their separation from the world has made them more human than we who live in it. Nor shall I remark on the success with which their generosity covers what the dictionary is pleased to call poverty. So far as concerns their celibacy and their devotion to a religious life, delicacy and a deep consideration withhold me from comment. As a world within itself Des Moines is all-sufficient. Blessed have been the hours of our brief sojourn here. We carry with us from this spot happy remembrances and we trust that as worldlings we have brought to it no jot of contamination.

But to return to *Homo sapiens*. Are we as wise as the good old Linnaeus believed we should be? Wisdom is certainly attributed to us, but is it really ours? How many of us would attempt again even the doctor's examination, not to mention an I. Q. determination? A close friend of mine, after a severe illness, could get no word from his physician as to whether he was whole or broken. In despair he betook himself to a life-insurance company, underwent an examination, and was accepted. He did not insure, however, but paid his fee and went his way rejoicing. How many of us would invite a similar examination of our claims to wisdom? As one of the last surviving members of the rapidly disappearing School of Behaviorists, I beg of you in seeking the answer to this question to inspect with care certain of our reaction patterns. I do not refer to what may be called our nest activities, but rather to those performances that stamp us as *naturae investigatores americani*. When we are not on vacation we are known to exhibit in a highly specialized environment and before the young of our species a remarkable set of responses that the world at large calls teaching, and when we can gain the laboratory sanctum we indulge in another class of performances—mostly in great privacy—that have received the designation re-

[1] Presidential address read at the annual meeting of the American Society of Naturalists, Des Moines, Iowa, January, 1930.

search. These two reaction types afford to those who observe our behavior the chief body of evidence for calling us men of wisdom. Let us scrutinize them more closely, and first:

Teaching

Of teaching there are three kinds—by example, by the voice and by the printed page. How easy it would seem to select the words of truth from the past, print them in an inviting and acceptable form and place them in endless editions before the young. But how different is the real task! One text in science is scarcely out before another is jostling at its heels. Publishers strive to start the new volume with the impress of the new year. Everything must be up-to-date, and that date must be now. We seem to forget that the best things in science happened before A. D. 1930. Not that a recent discovery should be ignored, but much that is important in science is far from recent, yet calls for comment. The few best texts hold their own, not because they are so much up-to-date, but because they come down-to-date so well. The intensity of our interest in the present appears to have dulled our sense of the historical. To appreciate Aristotle, it is well to recall that the compound microscope first came into use a little after 1600 A. D.

In preparing our texts and papers do we strive to write so as to engage the interest of our readers? Most of us, I fear, do not. We are obsessed with the idea that the subject-matter of our particular science is so innately interesting that we have no call to pay attention to style. To us the form of written presentation counts for almost nothing. Consequently many a worthy pupil turns down our printed page and, like the lovers in the "Divine Comedy," reads no more that day. How many times did I meet the simple statement that the human body contains about 59 per cent. of water before I grasped this obvious fact, and how many of my pupils have read this declaration, only to forget it forthwith? It took Sir Arthur Shipley to catch the waning attention by the simple sentence, "Even the Archbishop of Canterbury comprises 59 per cent. of water." After I had read this passage I asked an English colleague why Sir Arthur had in this way singled out the archbishop, but he assured me that there was nothing associated with this worthy prelate that called for special comment, and that this dignitary had obviously been selected only to serve as an example of our species. We Americans with our "Wets" and "Drys" are perhaps not so fortunately supplied with telling personalities. Who would hazard on this point a declaration of the percentage composition of our dry President at the White House and of his recent wet opponent in New York?

Another custom that we have which makes our texts less inviting than they should be, if not actually repellent, is the impersonal way in which we treat our subjects. Science itself may be impersonal, but the discoveries of science are far from being so. No major scientific discovery has ever been made without involving a personal situation, and often a most interesting one. Who can read von Baer's account of his first view of the mammalian egg without a thrill of excitement? He began his search for this important structure in 1826, and he completed it successfully the following year. In his autobiography he records the physical strain and damage to health that he suffered from the long hours of microscopic work that this investigation cost him. "And so it happened," he says, "that in the course of a year, I shut myself up in my shell while the snow was still on the ground, and when I again ventured out to cross the garden wall only a hundred steps from me, I was astounded to find that the fields of rye were in the ear." This is the application and energy that brought to light the

mammalian egg, a demonstration that an ordinary student can now make in one of our laboratories in half an hour or so. Yet the first time it was done, it required long-sustained human effort. How slight is our record of such achievements!

In an otherwise admirable book on life published only a few years ago, novelists and poets are named galore, but scarcely a hint is given as to those whose work fills most of the pages. Without converting our scientific texts into historical ones, could we not to advantage make them somewhat more personal? Light in this direction is already dawning.

What has been said of teaching by the printed page applies almost equally to teaching by the spoken word, and yet there are important differences. In the lecture or in the informal talk, the teacher has the pupil down, so to speak, at least for a limited time. What are the momentary advantages in this situation? Chiefly, emphasis and accentuation. In a good talk topics should be treated by us as in a newspaper. Some should be in headlines, some in leading type; some should be stated in full and others in abstract. In brief, the whole situation should be given light and shade. Thus a picture may be sketched. But how often our outlines blur, our colors run, and the whole composition loses point! Who, then, can blame the novice for lack of interest, or even for falling asleep? Perhaps the real art on such occasions is to sleep in one's own lecture. I knew of but one instructor who succeeded at this trick. The class was not large, it was two o'clock in the afternoon, and the season, a warm spring. With interested eyes we watched the struggle between our beloved teacher and Morpheus. First one was on top and then the other, but the remarkable fact remained that the lecture went on. I confess that it was a very deliberate one, but it hung together, and in the end it was complete. We looked up to our professor as an unusual character, as in fact he was, for he had accomplished two things in one, a nap and a lecture. He was not what would be described as a hustler, but in this instance he had what might be called double-barreled efficiency. He has long since left us. Peace be to his ashes, for he was a most revered teacher. I can not, however, recommend the napping lecture habit. It is too dangerous a pastime, and to carry it off successfully calls for an ability almost equal to that of a genius.

If the ease-loving instructor has his pitfalls, so does the hyperkinetic one. High-strung and on the jump, like the proverbial flea he is never where you expect him. He deluges his hearers with statements meant to inform, but poured out at such a rate as to be unintelligible. I once looked into the note-book of a student who had been through an hour of such treatment. It revealed a succession of half-completed sentences concluding with the statement: "We now see that the frog's mesoderm regularly takes origin from the entoderm," to which was added the pious ejaculation, "Thank God!" How often, after such an experience, have we felt that we would have had our money's worth had half as much been offered us. Walt Whitman knew something of this feeling when he wrote for another brotherhood what might perfectly well apply to some of us.

When I heard the learn'd astronomer:
When the proofs, the figures, were ranged in columns before me;
When I was shown the charts and the diagrams, to add, divide, and measure them;
When I, sitting, heard the astronomer, where he lectured with much applause in the lecture room,
How soon, unaccountably, I became tired and sick:
Till rising and gliding out, I wandered off by myself,
In the mystical moist night air, and from time to time,
Look'd up in perfect silence at the stars.

May it be given us not thus to empty our lecture halls.

And now a word or so about teaching by example. If teaching by the printed page and by the voice are the mechanics of our occupation, teaching by example is the psychology of what we do. Nowhere else are relations so subtle and intricate as here, and nowhere else is comment or suggestion so uncertain. On the one hand, a pupil may imitate, at least so far as within him lies, every act of his beloved teacher, or on the other hand, in utter condemnation he may do exactly the reverse. Examples of both courses are known to us all. Not many years ago two young men developed such a striking resemblance to their mentor that they were commonly known as the "blank" twins; the term "blank" standing for their superior's name and not for the usual expletive. I once heard a distinguished zoologist declare that his more distinguished teacher and predecessor had been to him an example of everything he should not be. How marvelous and unaccountable are our natures!

On the whole I am inclined to lay more stress on the principle of contrariness than on that of imitation. In my experience the imitators yield ultimately less admirable products than their opposites. Contrariness in students is in my opinion of great pedagogic significance. The pupil, like the child, is greatly excited over a taboo. I believe the surest way to get books read is to cover them with brown paper and hide them on a shelf, or to lock up the set in a case with glass doors, and mark them, "Not to be read by students." I well remember in my early days as an assistant in the laboratory a text on anatomy, from which, through vandalism, two pages had been removed. It is not an exaggeration to say that within a week half the students in the class had looked up the volume elsewhere and inspected and read the missing pages. They believed these pages to have been removed because of objectionable matter. So prone are we to reverse regulations.

Since this habit of mind, rather than that of imitation, seems to be a mark of budding genius, I suggest that we as teachers cultivate it in our pupils by assuming in ourselves a number of minor vices, the opposite virtues of which we hold to be beneficial for those whom we teach. I believe I have never before advocated any vice, but as I mature I am forced to admit that a really virtuous world can show up well only if it includes a few examples of vice by way of contrast. And now a few words about our second reaction type.

Research

If what we impart in knowledge and practice is the trunk and branch of the tree, what we deliver by research is the living twig and shoot. Just as the growing tips are essential to the life of the tree, so is research to the vitality of science. Every really first-class teacher does research. To quote Sewell, with a slight change of tense, "No upward growth can be hoped for except from teachers who can produce knowledge as well as impart it." This statement is now universally admitted, and it behooves us in our adjustments with the various organizations with which we are associated to insist upon proper provision and time for this activity. It is a short-sighted policy for any institution of higher learning to impose such an amount of routine on any of its scientific staff that research becomes impossible for them. One might as well cut off their food or sleep and expect them still to teach successfully. It is a fortunate omen that in many of our best institutions the choice for staff appointments turns on research ability. An able investigator may not always be the most skilful teacher, but he is the safest gamble for such a high appointment.

Science is in no sense mystical. It is based on clear, sure vision and it has developed in those races that look thus on the universe. It is essentially an occidental product that is gradually perme-

ating the whole earth. Of European origin, it betook itself with the discoverers to the New World. In the Orient it was quickly accepted by Japan, and there is every reason to believe that notwithstanding the national upheavals in progress, it is making rapid strides in China. It moves more slowly in India, probably because the magician and the necromancer have so strong a hold upon this people. The truths of science do not emerge from some deep recess of the human soul, but are the results of direct observation. No less a thinker than Leonardo da Vinci, who knew life in its fulness, declared that "all knowledge is vain and erroneous except that brought into the world by sense perception." Truth thus brought forth has no restriction. In the words of Sir Humphry Davy: "Science, like that nature to which it belongs, is neither limited in time nor space; it belongs to the world and is of no country and no age." And to quote from the biological side, von Baer has said, "Die Wissenschaft ist ewig in ihrem Quell, unermesslich in ihrem Umfange, endlos in ihrer Aufgabe, unerreichbar in ihrem Ziele." This is the dominion of scientific research. In this great field we work. No other realm of human endeavor can offer equal possibilities.

Do we cultivate this field as we should? Are we diligent in effort, intellectually honest, not only with others but with ourselves? Are we scrupulously careful to be as free as possible from error and unmistakable in statement? If so, we have little to concern us, but, as every one knows, the pitfalls are many. Even the choice of a title for a discourse or a publication is no simple matter. I recall that once in my youth I was asked to prepare a paper on some aspect of the stem of the vertebrate brain. I chose as a title, "Diencephalon, Mesencephalon and Metencephalon," and I was awakened from my slumbers under this mass of verbiage by a comment in the program of the proposed meeting to the effect that notwithstanding its title my paper would be given in English. Nor can I forget my unsuccessful attempt at this early stage to dissuade a fellow worker in our laboratory from heading his address, "The Chondrocranium of the Blue-tailed Skink." As I now look back through the years, this title still rings forth with a certain poetic rhythm such as one hears in few like efforts. Another member of the laboratory, a moderate purist, insisted once on publishing on the brachial and lumbosacral "plexi" of a certain animal. Hardly had the paper come from the press when to our mutual dismay we read from the pen of a real purist the crushing comment that "plexus" was not a second, but a fourth declension noun, and that its singular and plural forms were the same. I made a hasty survey of my early steps in classical education, only to conclude that at that time of life I was probably more interested in "puella, puellae, puellae, puellam" than in the more advanced declensions. But classical language must have its place, even in the titles of our papers, which reminds me that in choosing a designation for the present effort, I have attempted to please both sides. As you can see, one half the title of this address is as vitally direct and simple as words of about one syllable can make it. The other half forces Latin and Greek to look fresh and blooming, for it comes from a source as dry as dust. "Kim Kurmah" is Sanskrit for "What are we about?"

Speaking of titles reminds me of the body of the text. How blissful life would be if research without further ado would transform itself into the orderly written page. But most of us, I believe, suffer from the pains of composition. Clearness and brevity are the essentials of scientific writing. But whether we use capitals, semicolons, colons or even sentences sparsely or freely is not important. A legal acquaintance not long ago told me that in formal documents now-

adays the only admissible punctuation mark is the period, and considering the use of the capital and the break in the line, he doubted if that sign is really necessary. Perhaps the best rule in punctuation is that once employed by an American wit, who left out all signs in the body of his laugh-provoking composition and concluded it with a couple of pages of colons, commas and the like, with a note to the effect that each reader might distribute them to suit his own fancy.

Even so well established an element in composition as the sentence may come in for its share of revision. A sentence, as I understand it, is such an amount of writing as can be read conveniently in a breath. Sentence structure implies reading aloud, and the sentence itself may be regarded as the unit in a respiratory form of composition. But how many scientific papers are composed to be read aloud? Fortunately or unfortunately, almost none. We write to be read in the depths of silence. Since the flow of thought is continuous, it has sometimes occurred to me that we could better imitate the clarity and continuity of this flow by writing our words in uninterrupted series than by breaking them into sentences. The unpunctuated stream of text that flows over some thirty-five pages of a part of Joyce's new Odyssey may be a worthy example to those who would change language from a respiratory to a cephalic level. But what a frightful tumult this change would cause in the breast of a conservative nature, who, like poor Beckmesser of the stage, loves form so deeply that his best efforts yield nothing else. Why use even a parsable sentence if it conveys almost no idea? Yet some of us delight in talking for conversation.

But enough of trivialities. We must be serious. What in this inviting and almost unlimited field of research are we really about? And here, in accordance with our tastes, we mutually part company and scatter in many directions. Some seek to describe all living plants and animals and to show, as in a Sears-Roebuck catalogue, pictured examples of each kind. To them the temple of their devotions is the museum, once the home of the nine Muses, as attendents on Apollo, and now a huge catacomb of mummified nature. Here the world of living things is epitomized, that we may understand at a glance what a gigantic task beset our ancient progenitor Noah in the days of the great flood.

Others there are who seek to follow the wanderings of animals and all that they have done in transporting themselves and others from place to place. What a strange glimpse into nature they give us! I once asked a budding student of history who had discovered America and received the immediate reply, "Columbus." My look of doubt provoked the retort, "But you do not believe in Leif Ericson as the real discoverer, do you?" No, surely not. America was discovered by an Oriental horde which made its way from the Old World through the Bering Sea connections into the New World, to establish there that race whose members sat on the shore of San Salvador and watched with open-eyed wonder as Columbus rediscovered this land. Over the bridge from Siberia to Alaska and back again surged the animal life of two hemispheres, and yet our school books still declare for Columbus. Wonderful as his achievement was, an Oriental preceded him. This is one of the lessons taught us by naturalists who study the wanderings of animals.

Then, too, there are those who seek glory at the scalpel's point—the anatomists, the morphologists, the cytologists, the embryologists and a host of other "ists" who crowd institutions proudly called laboratories, as if these abodes had a monopoly on work. Some of these delvers find much in the larger animals, in what Shylock in the play calls the "harmless, necessary, cat." Others at-

tempt to expose to view the inmost parts of creatures so small that scores of them might dance on the head of a pin. These workers use microscopes, microtomes, micro-apparatus of all kinds and an infinite array of special fixatives, preservatives, stains and the like, all calculated to catch and hold the evanescent phases of life. But what they study in the end is for the most part preserved, often as perfectly as an ant in amber, but very, very dead. Does it really represent life? Who knows? Many believe so, and with such vehemence that their credo has already been written, beginning, "I believe in cytoplasm, in the chromosome, in microsomes and centrosomes, and in neurofibrillae, etc." But are the followers of this faith justified in the transfers that they make from the dead to the quick? Are we sure that what we see in a beautifully stained preparation is really in the living tissue? In my opinion we must heed von Uexküll's warning: "We have reckoned without our host, and the host's name is Life."

It is an easy transition from the field last mentioned to that of genetics. How do we as human beings come to be what we are, and how do all other living things reach their proper goals? Strangest of processes! That a jot of living substance from a living creature should grow into a bug, a cow, a whale or a man, according to its source! Such, however, is the fact. To keep these processes of growth running true that the creatures may reach their proper destinations, we have imagined a host of demons, the determiners, the biophores, the genes, whose special business it is to see that the goods are delivered. From our very earliest infancy they direct our course of growth, or if in this course two avenues are open to us, they see that we do not choose a third. What lack of confidence this oversight implies! Is not the growing substance capable of managing its own affairs? May it not increase in accordance with its own nature? Why must these controlling agents be superimposed on a process that may really be scheduled to run itself? The redundancy reminds one of the Irishman who begged his neighbor to lend him the loan of his knife. Why not dispense with all this governing superstructure and let protoplasm do its own work? No chemist calls on determiners to make the oxygen of the air unite with hydrogen to form water. These things take care of themselves, and whatever it may be that brings them to pass, it adds nothing to our understanding of the process to superimpose an assumed control. Of course, organic growth is enormously complex as compared with the formation of water, but who bothers about a determiner of the weather, for instance? This natural change runs its own course, grows, so to speak, in its own way, and yet is as law-abiding as any organism. Why not give protoplasm an equal chance?

And so we might go on from clan to clan, to ecologists, to parasitologists, to physiologists, to pathologists, to evolutionists and to a host of others, all of whom seek answers to their own questions in their own way. Were we to ask these workers one and all what general problem interested them most, I suspect they might agree in desiring to know how it is that we moving, sentient, thinking, dreaming beings come from aggregates of protons and electrons operating under quanta regulations. This question was once answered by a clear-headed Catholic, who declared that at a given point in the course of our evolution from the lower orders of creation the Almighty infused a soul into the creature, and from that moment on it was what we are, and worth saving. This implanting of the soul, my Catholic friend said, is what some biologists might call a mutation, but what a Catholic would call a miracle. The difference between our views, he maintained, was paper-thin, almost a matter of phrasing.

But frankly I do not believe the question can be disposed of so easily.

I once read that Sir Isaac Newton had expressed the hope that in time the activities of living things would be understood in the same simple way that he had been able to understand through the universal principle of gravitation, the movements of the heavenly bodies. What biologist has not entertained in one form or another this very hope, but are we justified in such an aspiration? Eddington, in his recent book on "The Nature of the Physical World," tells us that one of the most remarkable conceptions entertained by modern science is that of the almost vacuous nature of solid bodies. Each of us is made of atoms, no longer the miniature billiard balls of the older physicists, but aggregates of protons and electrons probably arranged like minute solar systems. Such being the case, an atom is vastly more empty space than solid substance, and, to follow Eddington, if our bodies were reduced to real solidity by the condensation of our atomic structure, we should go down to a pinhead in size. In this way our too, too solid flesh would melt and shrink to a mere speck. Will this speck of real substance suffice for what I am? The idea is novel, to say the least.

But to return to Newton. His conclusions, and with them his hopes, appear to need some modification. It seems that the core of the universe is not so lucidly understandable as he thought. The modern physicist, for example, has his doubts about the absolute application of the idea of cause and effect in atomic and subatomic relations. In the interaction of colliding quanta and electrons, it appears no longer possible to prescribe with perfect accuracy the courses taken by the separating elements. We are compelled to admit, even in the most rigid theoretic consideration of the subject, a minute angle within which anything may happen. These ultra uncertainties are always present, yet because of their excessive smallness they have no practical significance for us, nor for other bodies of our size. Nevertheless, they must be regarded as indicative of a fundamental, though extremely minute, flaw in the Newtonian conception. They imply a radical modification of this view in line with that advanced by Einstein. They are incorporated in what is termed Heisenberg's principle of uncertainty.

If this principle rules in the very heart of mechanics, why trouble ourselves about the uncertainties so characteristic of the performances of organisms? But the Heisenberg principle is only of ultra-atomic application, and it is therefore clear, as Bridgman has pointed out, that biologists are not justified in carrying it over to those massive types of response associated with the bodies of living things. Undoubtedly the electrons and quanta of the human body exhibit all that they should in conformity with the principle of uncertainty, but such modifications are so infinitely small compared with our bulk that we see nothing of them. Their effect is like that of heat in changing the volume of a body before accurate measurements of length were possible. The outcome of Heisenberg's principle, though present in us, is not sensed by us. It is not for a moment to be supposed that if we fall from a height we do not in every reasonable way exhibit the acceleration of gravitation as we descend to the earth. Nor are we to believe that the main outline of the chemistry of our bodies has not already been correctly described. Here again we know full well that our bodies follow classical models. To be sure, we are units whose integration is unusually extreme, and we know that our dissolution is accompanied by a loss of something which, as in the separation of a verse into its words or a melody into its notes, is nowhere found among the independent elements. This idea,

the burden of modern emergent evolution, is recognized by all. But this way of viewing organisms does not exclude the opinion according to which the living animal continually reveals peculiarities seen in the most lifeless material. We appear to have arisen exclusively from such material; we exhibit its properties, but we have much more in us than these simple properties, though not so much as some would have us believe.

Entelechies, mnemes, élans vitales, and the like, have had their days, for, notwithstanding the insistence of Driesch, Semon, Bergson and others, we are not as yet obliged to assume these vitalistic elements in our efforts to understand living matter, any more than we are called upon to accept for biology the limitations of classical chemistry and physics. No student of the problem can fail to see that chemistry and physics are growing subjects, whose methods and conclusions are bound in the course of time to exhibit ever-advancing changes. Their growth will force them more and more to invade the field of biology, as in fact they are already doing. Here they will meet with problems peculiar to this science, and their attack upon these problems will modify their conclusions and outlook as much as it will illuminate those of biology. It is impossible to predict what, in the whirligig of time, the outcome will be. Will the inorganic sciences absorb biology, or will biology absorb them? Possibly the type of union, if it occurs, will be more in the nature of fertilization than absorption, and a new science will be born. But whatever may transpire, one problem in this general field is bound to loom large, and that is the problem of organization. How do the parts in larger or smaller units interact? What makes integration possible? This is as much a problem in ultra-atomic affairs as in organisms or in stellar bodies, and it is undoubtedly the general problem that occupied Newton's mind when he expressed the hope that the activities of organisms would be understood in the same way in which the movements of the heavenly bodies had been elucidated.

At sight of this general problem, many biologists are smitten with one or other of two strange phobias. There are some who, on hearing of analysis and disintegration, fall into paroxysms of fear lest the most precious things in life be lost, and there are others who are compelled to close their eyes in the presence of living things, lest they see complications beyond their present ken. It is difficult to say which phobia is the worse. The cure is that practiced on four-legged nature—take off the blinders and lead the afflicted creature near enough to the object of his fear that he may see its real innocuousness. The analytic process in biology is a perfectly innocent procedure that has shown us that down to the very bottom of our natures we are part and parcel of the universe around us. This is no small accomplishment, but as a result of such success we must not close our eyes to the fact that living substance may be so organized that to understand it in its totality requires a consideration of its united relations as an intact whole. While many of us work in analytic ways, it behooves us to keep our eyes continually open to those integrated aspects of nature which we recognize as individuals of higher or lower order and which exemplify the complications of life. It is in this direction that we are likely to meet with scientific novelties of the first order. The importance of maintaining this attitude of mind has been clearly set forth by Bridgman, who in his recent volume on the "Logic of Modern Physics" has declared that "it is difficult to conceive of anything more scientifically bigoted than to postulate that all possible experience conforms to the same type as that with which we are already familiar." And after we have done our best in giving our small contributions to the solution of this major problem, we can do little more than follow the rule of one

of our foremost countrymen, Benjamin Franklin, who, in speaking of his scientific beliefs, declared: "I leave them to take their chances in the world. If they are right, truth and experience will support them. If wrong, they ought to be refuted and rejected."

The effect of what we as naturalists are about may appear to have only a remote bearing on the civilization of our day. Who cares how many species of Strongylocentrotus there are in the sea? But we must remember that precisely this kind of knowledge about mosquitoes, about their distribution and their life histories made possible the building of the Panama Canal. Most of us are retiring and modest creatures, and as a result we are given to underestimating our own performances. It is only from others that we may expect a generous appraisal of our work. In an address given a few years ago at the Washington meeting of the American Association for the Advancement of Science, the then Secretary of State, Mr. Hughes, declared, in speaking of scientific workers: "If civilization is to advance, it will be your doing, and the best we can hope for governments is that they will not stand too much in your way." And on the same occasion, Mr. Coolidge, at that time President of the United States, said: "We trust ourselves to you with some doubts as to what you may finally do with us and to us, but at least with firm conviction that your activities will save life from becoming monotonous. And besides, we realize that if we did not give you our confidence, you would go ahead without it." These statements indicate the respect, not to say the awe, with which we are regarded even in high places. But what, I am sure, we most wish for is not simply to influence those in supreme stations, but to spread science throughout the world, not as a body of fact, but as a way of life. As Findley said a few years ago: "For the community as a whole, it is not the acquisition of a knowledge of the facts of science, but the becoming imbued with the spirit of science that is of chief importance." This life is full of questions that range from those of international procedure to such as stand between parent and child. The answers to such questions may be passionate, with war and undue chastisement as the result. The scientific spirit does not seek a passionate answer. It seeks one based on a deliberate and impartial consideration of the circumstances. Thus truth is attained, and decisions based upon truth have lasting strength. A civilization that seeks in this way to resolve its difficulties, large or small, is permeated with the scientific spirit, and to infuse this spirit into the world is one of the things that we should be about.

WHY THE 200-INCH TELESCOPE?

By Dr. ELIHU THOMSON

THE GENERAL ELECTRIC COMPANY

THE object of the society which I now address, namely, the American Philosophical Society, the oldest society of the kind in America, which has existed for about two hundred years, is to coordinate knowledge in all the different fields, to seek expansion of that knowledge in new directions and to assist in the progress obtained by improving the facilities, not only in the study of science but also in the humanities and in all phases of human effort, leading to a better understanding of our life on this earth. It is here that the leaders in investigation, the explorers, the advance thinkers, may present their results and have them recorded. This, indeed, is philosophy in its broadest sense.

As civilization spreads, as populations increase, there comes, naturally, the need of a widened sphere of activity, more resources to conserve the recorded results of the work of the eminent men and to make adequate provision for the inevitable expansion of the work in the present and the future.

The society is fortunate, at this time, in having started on a period of expansion which will eventuate, we hope, in realizing the objects which I have just pointed out. Fortunately, too, from Franklin's time, the American Philosophical Society has been uninterruptedly active and has attracted to its meetings and programs leaders of thought from all parts of our great and growing nation, as well as from abroad. Its limited quarters are now outgrown, and it must seek its expansion elsewhere than in this hall. I need not dwell on the details of this enlarged program, which have been carefully worked upon by the officers of the society and which it is earnestly hoped can be carried through successfully.

My present task is quite different, although, in a sense, there is an analogy. The astronomers have greatly increased their facilities, extended their observations and have approached the need for more effectual instrumental equipment in the exploration of the great universe in which we exist. I may quote here a paragraph from an article which was published in *Harper's Magazine* for November, 1929. It was from the pen of Dr. George Ellery Hale, honorary director of the Mount Wilson Observatory, near Pasadena. He begins his text with these words:

> Astronomers, like other men, spend most of their lives in hard and often tedious routine work. They are, however, sometimes fortunate enough to take part in a great adventure, and it is of such an adventure that I am now writing.

The title of the article of which the quotation just made is the opening paragraph is "Building the 200-inch Telescope." I commend to any one who is interested the reading of that article, because Dr. Hale has presented in a brief form, from the astronomers' standpoint, the reasons for and the advantages to accrue from the possession of the proposed giant instrument.

It will not be my function, in dealing with the subject of the 200-inch telescope, to treat it as an astronomer, nor shall I treat it as a designer of a huge instrument, surpassing in magnitude anything before undertaken, would treat it. I shall not compare it with a battleship in cost, although it will involve a large expenditure, but what I have to say

will concern the heart and soul of the great instrument, so to speak, namely, the mirror which reflects the light from the distant celestial objects and brings it either to the photographic plate or to the human eye.

There exists at the Mount Wilson Observatory, near Pasadena, the largest telescopic instrument in the world, usually spoken of as the 100-inch. The mirror, which, of course, is the most important part of the instrument, is made of a great block or disk of glass, about one hundred inches in diameter and about thirteen inches thick, and this block weighs, I think, about four or five tons. It took a long time to melt the glass; indeed, it was difficult to find any glass-maker to undertake to make that glass disk, there were so many uncertainties. Three large pots of glass were poured into a mould and cooled through months of gradual loss of heat so as to anneal the glass and prevent its going to pieces by uneven contraction and expansion. But that was only a portion of the difficulty. Once obtained, the glass had to be worked into the form of a disk having a slightly concave surface, and this surface had to be shaped with the greatest accuracy to the form of what is known as a paraboloid of revolution, so that the light of a distant star, for example, would be brought to a single point, or as near to a point as possible. The light of a star falls on every part of the surface of the mirror one hundred inches across and from that face must be reflected so as to reach a focus many feet away, all parts of the extended surface cooperating to direct the light to that distant focal point. The least divergence from the proper path of the light ray from any part of the surface is destructive; the image is imperfect, blurred, more or less indistinct; the fine definition, as it is termed, is lost.

I saw the 100-inch mirror under preparation at Pasadena by Dr. George W. Ritchey. The grinding and polishing is nothing as compared with the time it takes to figure or give final exact shape to the mirror surface, that is, to give to it its final form within a few millionths of an inch. This is to say that the accuracy of the surface must be exceedingly great, inconceivably great for most people to visualize. When the surface is being formed by polishing it by a gently moving polisher, the glass is slightly heated and distorted. This is enough to make it necessary to stop the work for the day and put the mirror to bed, so to speak, under five inches or more of felt covering until the next day.

The next day the first operation is to uncover it and make tests by rays of light and optical means as to its form in different parts or zones, as they are called. These tests completed, the polishing goes on with the greatest care not to overrun or spoil the work already done, until at last, after about two years of this process with the 100-inch, the desired figure or shape was attained, be it remembered, not by grinding, not because one polishes the surface, but by polishing in just those places and to just that extent as will remove a very small amount of the glass and give it the paraboloidal final figure. Thus arose into being the present 100-inch mirror, the largest in the world and the basis for the largest existing telescope.

Popularly, one might imagine that the making of the mirror itself completes the work, but it does not. The mirror has then to be mounted in a balanced position so that it is not distorted by changing its position. This involves an elaborate scheme in itself. It has to be mounted so as to be turned in any direction facing the different parts of the heavens without being bent or even slightly distorted; it has to have a very thin coat of silver deposited on its front surface, because it is not like the ordinary looking-glass mirrors; one does not

look through it, but at it. The light falls on its front surface and is reflected from the exceedingly thin, polished film of silver which has been deposited on that front surface by chemical means. But that is not all, by any means; there is a great deal more. Such a mirror, however perfect in its make-up, its construction, its mounting and its silvering, is still subject to distortion whenever the temperature of the air around it changes. The face and edges of the mirror naturally change their temperature more rapidly than the body, and glass being a substance expanding by heat, the change of even a very few degrees in one part of the mirror in relation to another part practically destroys the accuracy of its reflection and therefore the accuracy of the images which man is seeking to examine visually or to photograph. So much so is this the case that there always must be a consideration of the coming night as to temperature, and an effort is made to guess ahead of time what that temperature may be and means are provided for giving the mirror the temperature which may have been assumed—mistakenly, of course, in many instances.

I am told that the 100-inch glass mirror is rarely used with its full aperture or with a full opening or full face (the 100-inch circle) but its edge is often cut down more or less so as to lessen its effectual size, according to the sharpness of the images.

It is difficult, indeed, to convey in a few words the necessity for exceeding accuracy of shape or figure of the surfaces of these mirrors and to make it understood how little a disturbance will throw them off: or make them ineffective for the work for which they are designed. There is a number of fairly large glass mirrors in existence in the astronomical observatories of the world, but they all suffer from the same disadvantages of glass expansion which I have tried, in as brief as possible a way, to point out.

It is now about thirty years since I made the first experiment, comparing a small slab of fused quartz, or fused silica, with a similar slab of glass, as preliminary to further work. I formed on each of these a slightly concave surface, and then used well-known optical tests to show whether the figure was maintained under different conditions. The experiment was, naturally, imperfect, but I felt sure of the result. On having the two mounted so that I could have a distinct and clear image of a small artificial star or point of light when used with an eye-piece as a telescope is used, I found that by instantaneous application of a moderate heat or a small flame on the back of the glass slab, the image went immediately all to pieces, as we may say; that is, it scattered, all definition was lost. A similar treatment of the quartz slab showed very little change, and not until the back of the quartz had become quite hot was there a semblance of the disturbance that occurred with the glass.

This experiment, modest as it was, convinced me that there was one material suitable for the making of astronomical reflectors that would avoid many of the difficulties of construction and operation inherent in the glass-mirror telescope. I have kept the matter in mind, but only in recent years have I been able to extend the work to include mirrors of such size as would be actually useful in astronomical work. Dr. George E. Hale, himself, was one of the first to ask for blocks of fused quartz from which mirrors could be made.

What, then, is our task at the Thomson Research Laboratory at Lynn, of which I am director? This is a laboratory of the General Electric Company used for research. Is our task to provide the funds for the work? No. They are provided by certain funds which ex-

ist and which are devoted to this purpose. Is our task, then, to design and build the telescope structure of steel framing—admirable and huge mechanism as it will be? No, we have not that task; others will take care of that part of it. Then what is our task? The answer is simple; it is to provide the mirror, and this mirror body will have to include in it two new pioneer characteristics. The first is its great size, far beyond anything before contemplated. It will be twice the diameter of the existing 100-inch mirror at Mount Wilson and will, therefore, have four times the surface and be very much thicker. It may be six to eight times the weight of the glass mirror at Mount Wilson, or say twenty-five to thirty tons in weight. The second and more important pioneer character is in the material used for such a mirror. It is not of metal, as the great Lord Ross instrument was, speculum metal, six feet in diameter; it is not to be of glass, as in the most recently constructed instruments of large size. Glass, as I have pointed out, gives great difficulties. It is very difficult to melt the glass, get it uniform and cast it, with the subsequent slow cooling and annealing through months of time to avoid its splitting or fracturing by uneven cooling or having within it uneven structure. It is far more difficult to shape glass to the accurate figure demanded, as the building of the 100-inch mirror showed clearly. It is even difficult to use, on account of the deformity it undergoes by changes of external temperature, disturbing the direction of the light reflected from parts of its surface and spoiling its performance.

No, it is not glass that we shall use, but fused silica, or melted quartz, melted in an electric furnace at between 1,700 and 1,800 degrees Centigrade, which means more than 3,000 degrees Fahrenheit, or about the melting-point of platinum, a metal difficult to melt, as is well known, and which does not melt in ordinary flames or furnaces. The method we shall use, which we are using, in fact, on a small scale with great success, is, in general terms, one devised quite a number of years ago, and which consists in first melting a mass of good clean quartz sand in a circular mold in an electric furnace and obtaining thereby a disk or thick slab of melted quartz sand. This is, indeed, fused quartz, but full of tiny bubbles, which tend to make it lighter, but the melted sand has all the desirable properties of the solid fused quartz itself.

Now, what is the most striking and important of those desirable properties? Simply this, that it is a rigid hard material, almost expansionless by change of temperature. A bar of it a meter long, or a little over a yard long, if raised from ordinary room temperature through 1,000 degrees Centigrade, or about 1,800 degrees Fahrenheit (a very bright heat and one which is very near the melting-point of gold), expands only a half a millimeter, or about one-fiftieth of an inch. Considering this great range of 1,800 degrees Fahrenheit, it can well be understood that under ordinary temperature changes fused quartz practically does not expand or contract. It retains its dimensions.

Now if a mirror is made of such material it retains its dimensions and does not bother the worker in either producing it or using it. There is not the long task of polishing it and letting it cool between the efforts from day to day.

But I have spoken only of the foundation or base body of the mirror. I have not said anything about the second stage in its production. This comparatively rough, bubble-filled mass of melted sand, which is the underlying disk, has to be provided with a surface layer, more or less thick, of clear glass-like fused quartz, or silica glass. It will

have the same general properties, so far as expansion goes, and, therefore, will suit the purpose very well united to the sand backing. The first efforts were made by melting on to the fused sand backing slabs of clear quartz made in a different way, and the results were fairly successful. Fair mirrors could be made in that way, but at the suggestion of one of our skilled workers an experiment was made of feeding into an oxy-hydrogen blowpipe flame granulated or finely powdered crystal quartz (rock crystal) of high quality, and immediately it was found that a coating of clear quartz could thus be deposited upon any other piece of quartz. When oxygen and hydrogen are burned together in a jet, the temperature of the flame is high enough to fuse or melt silica, or quartz. By raining down through such a flame, the granulated crystal quartz is received on a surface much as ice deposits in clear layers on objects during a sleet-storm. In illustration I often use the analogy, only adding that ours is a high temperature sleet storm, with quartz instead of ice deposited in clear layers.

Extending this to a mirror, it was found that under proper precautions of temperature, the surface might be glazed with clear fused silica to any ordinary desired thickness by the simple process of introducing high-grade silica into a flame of such temperature as will melt readily the particles of silica as they pass through it towards the surface which receives it. In this case, of course, it is the surface of the mirror to be, as composed of the fused sand backing, which in the way I have outlined is covered with a layer of beautiful, clear, transparent fused quartz. When I speak of fused quartz or fused silica or silica glass, the same material is meant; the terms are used interchangeably.

It has taken considerable effort and time, and some money, to arrive at this stage in the operation, but the results are justifying themselves right along, and were it not so I should not have been ready or willing to tell you of the progress towards the making of the 200-inch mirror. We now feel that our task is indeed an enlargement of the scale of our operations. We do not, however, minimize the obstacles which will have to be overcome in enlarging to the great scale on which we must work when producing the 200-inch mirror. It is a gigantic thing in itself, but such a gift to science is a prize that is worth working for.

It has, of course, been necessary in doing this work and carrying it along, and the necessity will continue to the end of the accomplishment, that competent, enthusiastic coadjutors shall exist to take care of the very varied things which present themselves. They must, indeed, be both competent and enthusiastic. The work has just begun, and mirror blanks suitable for use in astronomical telescopes up to about two feet in diameter are produced and producible. These have all the desirable qualities which, of course, will be those of the great mirror. We can not speak of taking only months to produce the large mirror; we must speak of years. It may be two or three years before the large mirror is turned out, but every product of our work is itself an acquisition for astronomy, whether it be two-feet, three-feet, five-feet, six-feet mirrors, and we will go to our goal by steps. Every one of these interim products will be a useful and desirable thing for the astronomer; in fact, the construction of the 200-inch mirror involves the production of at least two or three others of less size to be used with it, in several combinations.

The process of actually shaping, the grinding, polishing and figuring of these

quartz mirrors, is practically the same as has been used in the making of the glass mirrors hitherto, and will be done probably at Pasadena under the care of the Mount Wilson Observatory optical staff, but with the great advantage that the work does not have to stop for equalization of temperature in the mass of the mirror as with glass, but can go on steadily, uninterruptedly, occupying days instead of years, and experience shows us that the material leads itself more readily than glass to the work of the optician.

The mounting and use of the great mirror will be the same, except for a great enlargement of scale, as they would be with a glass mirror, but there will not be the disadvantage of changes of temperature disturbing the accuracy of the work or its possibility. The fearsome process of using the sun itself as the object of investigation, for example, will not trouble with a mirror of fused quartz, as it would with a glass mirror. It is, of course, necessary to establish such an instrument in the best or steadiest air that can be found, little subject to currents of different temperature which disturb the passage of the light to and from the mirror in the atmosphere itself. Proper sites are even now being sought for the mounting of the great instrument.

The mirror blank itself will probably be made at the River Works of the General Electric Company at West Lynn, or nearby, and I wish to mention here the fact that the undertaking is carried on at the works of the General Electric Company without any idea of profit, but merely at the cost of labor and material, and a free gift is made by that company to the enterprise, of the engineering skill and existing laboratory equipment useful to the attainment of the end in view.

Naturally, the placing of the giant instrument is a problem in itself, but one which we can leave to the astronomers. We can leave also to the astronomers a description of what may be expected from the use of the giant mirror in the completed telescope, a great engineering structure itself, except to say in general that its light-gathering power will be probably not less than four times that of the 100-inch, but on account of the greater convenience this factor will undoubtedly be increased, as it can probably, in good air, be used without diaphragming down. Four times more light with equal accuracy means that the distance of reach of exploration is increased twice, which means that our visible universe is thus increased $2 \times 2 \times 2$, or the cube, or eight times. If the effective light-gathering power be in still greater proportion, as is probable, then we have the universe further increased, but this, of course, is not alone the meaning or object of the instrument.

Every problem which is present with the astronomer to-day will, with the superb instrument, be more easily reckoned with. Its greater capacity for gathering light makes it easier to use higher magnifications if the image is accurate. It may, therefore, lead to our more complete knowledge of the planets which belong to our own system and assist greatly in the investigation of other heavenly objects which appear in our sky. It may help to solve some of the problems connected with that most interesting neighbor of ours, the planet Mars, about which we can form hypotheses but with little chance, thus far, of confirming or denying their validity. The major advantage may be summed up in the term "greater and more accurate space penetration."

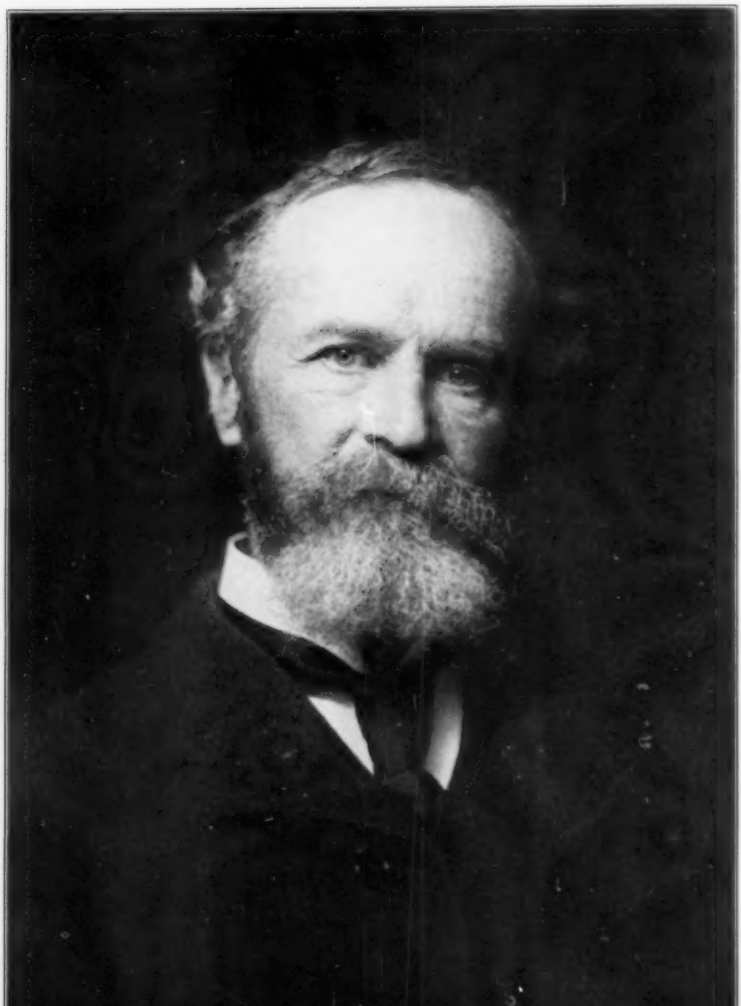
I can not close this statement without paying a tribute to our laboratory staff, who so far have borne the burden "and the heat of the day," so to speak, in the development which has so far progressed.

At the head of this staff is Mr. A. L. Ellis, assistant director of the laboratory, who has been most indefatigable in carrying on the development. They have all done their part, and have done it most enthusiastically and productively. I should like to enumerate them and credit to them their different contributions.

I will close this statement with a quotation from an article which I contributed to the New York *Sun* on "Electricity During the Nineteenth Century," which was published early in 1901. On the last of the twenty-five pages, the article concludes with this statement:

> The hands of man are strengthened by the control of mighty forces. His electric lines traverse the mountain passes as well as the plains. His electric railway scales the Jungfrau. But he still spends his best effort, and has always done so, in the construction and equipment of his engines of destruction, and now exhausts the mines of the world of valuable metals for ships of war, whose ultimate goal is the bottom of the sea. Perhaps all this is necessary now, and, if so, well. But if a fraction of the vast expenditure entailed were turned to the encouragement of advance in the arts and employments of peace in the coming century, can it be doubted that, at the close, the nineteenth century might come to be regarded, in spite of its achievements, as a rather wasteful, semibarbarous transition period?

And I might add now, "Has it been any better in the first quarter of the twentieth century?"



Wm James

PSYCHOLOGY IN AMERICA[1]

By J. McKEEN CATTELL

FORMERLY PROFESSOR OF PSYCHOLOGY IN THE UNIVERSITY OF PENNSYLVANIA AND COLUMBIA UNIVERSITY

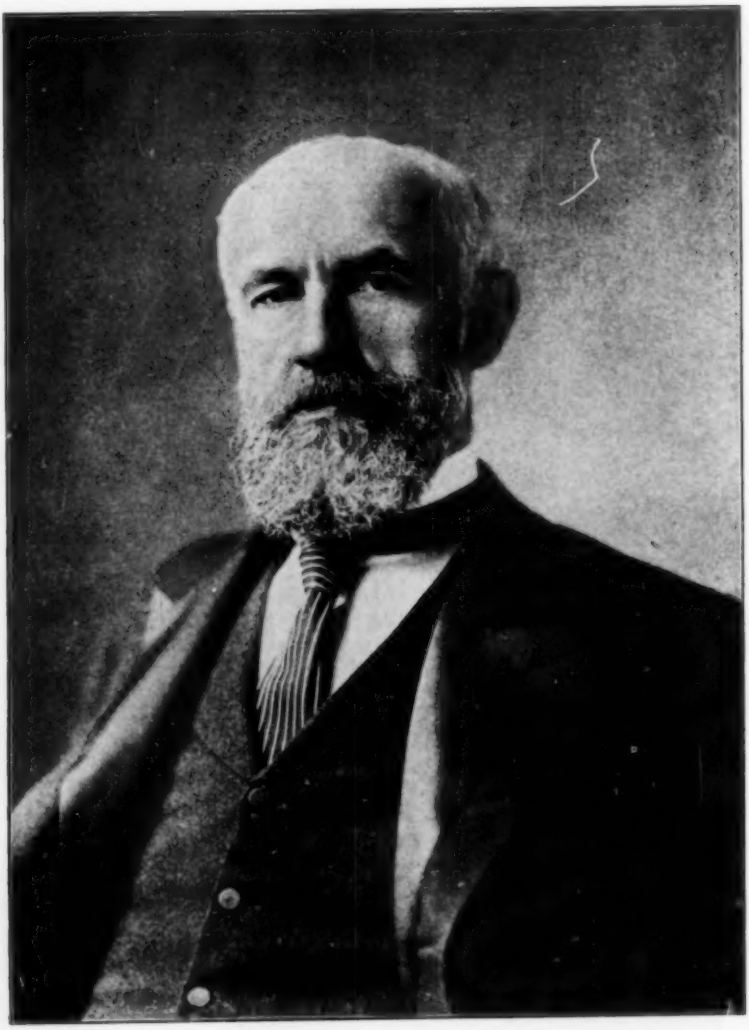
A HISTORY of psychology in America prior to the last fifty years would be as short as a book on snakes in Ireland since the time of St. Patrick. In so far as psychologists are concerned, America was then like Heaven, for there was not a damned soul there. Jonathan Edwards, the theologian, and Benjamin Franklin, the practical man, were our most typical representatives. In our colleges mental and moral philosophy was indeed taught, mostly Scotch, the importation of which was not prohibited in those days. Noah Porter, president of Yale University from 1871 to 1886, gave us the most elaborate text-book; James McCosh, president at Princeton from 1866 to 1888, performed the greatest service by sheltering physiological psychology and organic evolution under the cloak of Presbyterian orthodoxy.

There was no science of psychology in America fifty years ago; it may be that there was no organized science of psychology in the world prior to 1879. In that year Wilhelm Wundt established at Leipzig the first laboratory, Th. Ribot published his "La Psychologie allemande contemporaine," Francis Galton his "Psychometric Experiments," William James the first chapter of a work on psychology. In so far as psychology dates from 1879, this congress celebrates the jubilee of our science. The first congress of psychology met in Paris in 1889; the present congress marks the fortieth anniversary of our international cooperation.

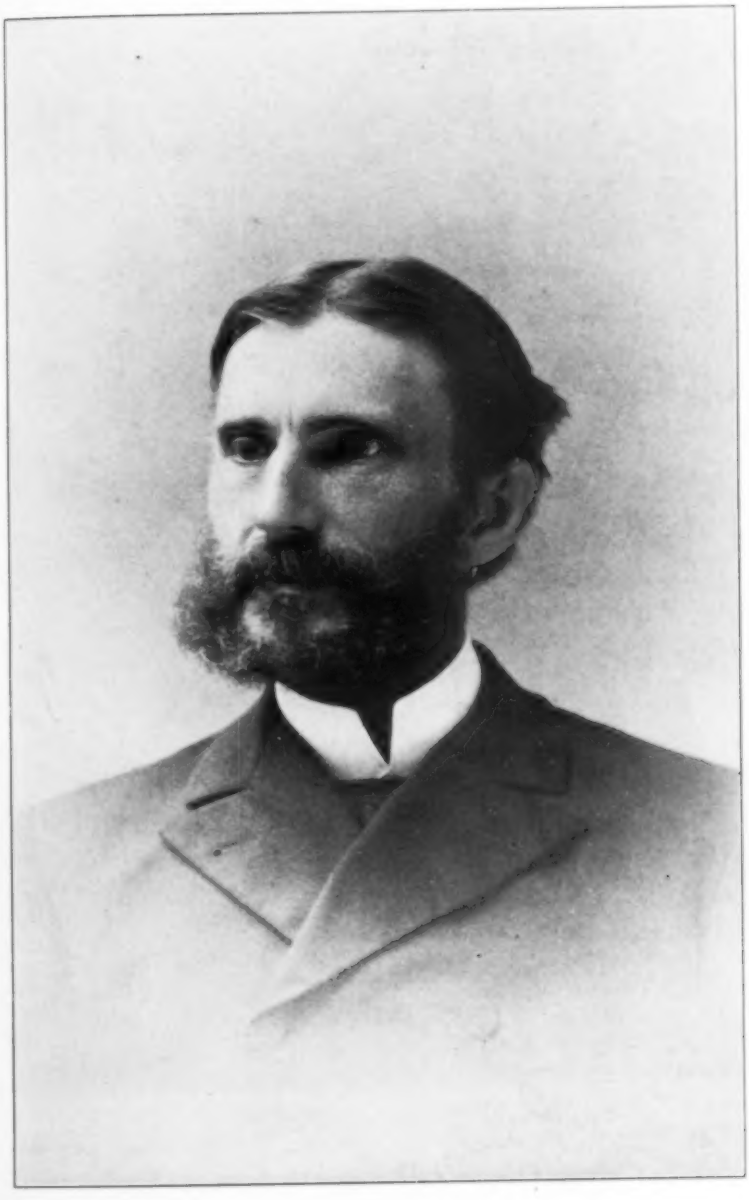
The pedigree of psychology, as of every science, can indeed be traced to Aristotle and the efflorescence of the Greek period, further back to the civilizations of Egypt and Asia Minor, dimly through the twilight and darkness hiding primitive men. If the making of fires and the use of tools, the cultivation of plants and the domestication of animals, were the beginnings of the physical and biological sciences, then psychology goes back to primitive speech, habits and customs. Perhaps the origins of psychology may be found in more remote pre-human, pre-mammalian and pre-vertebrate animals than those of any other science. The modern dog doubtless finds more differences between two individuals of its species than between a tree and a lamp-post that smell alike. Our early ancestors were mainly concerned with themselves, with their mates and their offspring, with the behavior of their fellows, of their prey and of their enemies. Satisfaction of desires, escape from danger and pain, efforts to foresee and to control the conduct of others, were the earliest and are the most fundamental of interests.

When such is so clearly the case, it may at first sight seem surprising that the sciences, both curious and useful, of matter and energy should have had an earlier origin and a more systematic development than the biological sciences, while psychology is only now taking its place among the descriptive sciences and has witnessed but its first beginnings as an applied science. The explanation is partly in the difference in stability and complexity of the objects of the different sciences. Matter is plastic to experiment and measurement; human behavior eludes experimental and quantitative methods. The motions of the solar system since its beginning are less

[1] From the Address of the President of the Ninth International Congress of Psychology, given at Yale University, New Haven, September 2, 1929.



G. Stanley Hall



George Trumbull Ladd

Josiah Royce.

complicated than the play of a child for a day. It is also the case that in the architectonics of science the mathematical and physical sciences are fundamental. Morphology and physiology are based on physics and chemistry; psychology on all these sciences. The foundations must be laid before we can build the upper stories, in which we may prefer to live and from which there may be the wider outlook.

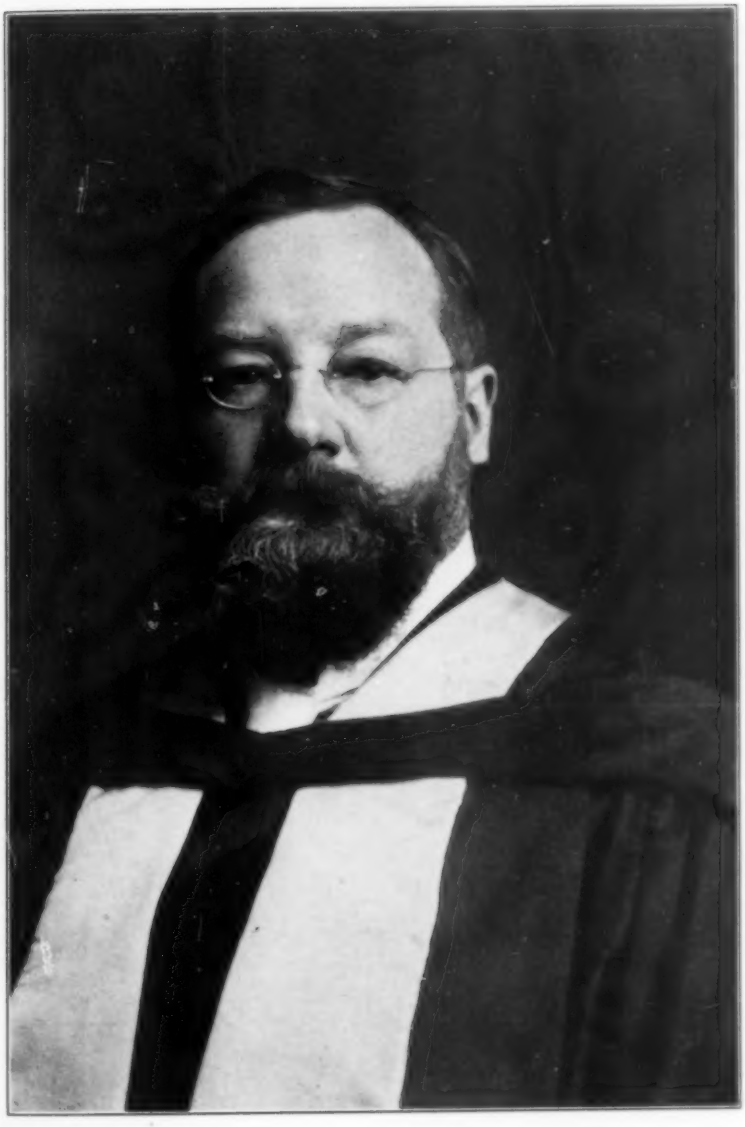
A less obvious reason for the late development of psychology is the circumstance that it is easier to satisfy needs and to control behavior by altering the environment than by altering individuals. The savage could learn to shoot an arrow from a bow or to move a stone with a lever more readily than he could strengthen his own right arm. He could obtain food better by planting corn than by developing his skill as a hunter. And so it is to-day. By increasing economic production we can do more for the welfare of people than by teaching them to be virtuous and wise. In America we have constructed a great civilization, not by trying to be civilized but by applying invention and organization to the exploitation of natural resources.

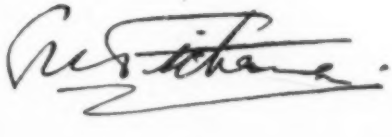
Psychology had to await the development of the exact and the natural sciences, whose objects are more open to measurement, whose contents are more basic, and whose applications are more useful. And it should be remembered that all the sciences, as we now know them, are comparatively new. The doctrine of the conservation of energy is only about as old as Professor Stumpf, the theory of evolution by natural selection about as old as Professor Jastrow. Modern physics and modern genetics are no older than the younger members of this congress. When sciences of earlier origin have made such notable advances during the lifetime of those now living, we may look forward with hopefulness to a corresponding development of psychology within the lifetime of our children.

Fifty years ago William James, born in 1842, was assistant professor of comparative anatomy and physiology at Harvard; Stanley Hall, four years his junior, was a student in Germany. As to other American psychologists there were—as Franklin said when asked if he had any children—"none to speak of." James was transferred to an assistant professorship of philosophy in 1880 and appointed to a professorship of psychology in 1889, resuming after eight years a chair of philosophy. He published in 1890 "The Principles of Psychology," a work of genius not often equaled in any science or in any language. Hall received the doctorate of philosophy from Harvard in 1878, one of the first awards of the degree, and was appointed lecturer there and at Williams College in 1880. In 1883 he became professor of psychology and pedagogy in the Johns Hopkins University, giving also the courses on philosophy. In that year he established the first American laboratory of psychology, unless we count as such the work by James at Harvard under physiological auspices, in which case it would antedate the Leipzig laboratory.

George Trumbull Ladd, eight days younger than William James, was called to a professorship of philosophy at Yale in 1881; he published in 1887 his "Outlines of Physiological Psychology," the first American book on the subject and, as revised by Professor Woodworth, one of the best. In that year there was established a lectureship and in 1888 a professorship of psychology at the University of Pennsylvania. This chair, held by me, was the first in any university here or abroad to be so named and in which the work of the professor was confined to psychology, the department being coordinate with philosophy and other university disciplines. In the laboratory were given the first experimental courses for students, the work at Leipzig and the Johns Hopkins having been limited to research.

Hugo Münsterberg.





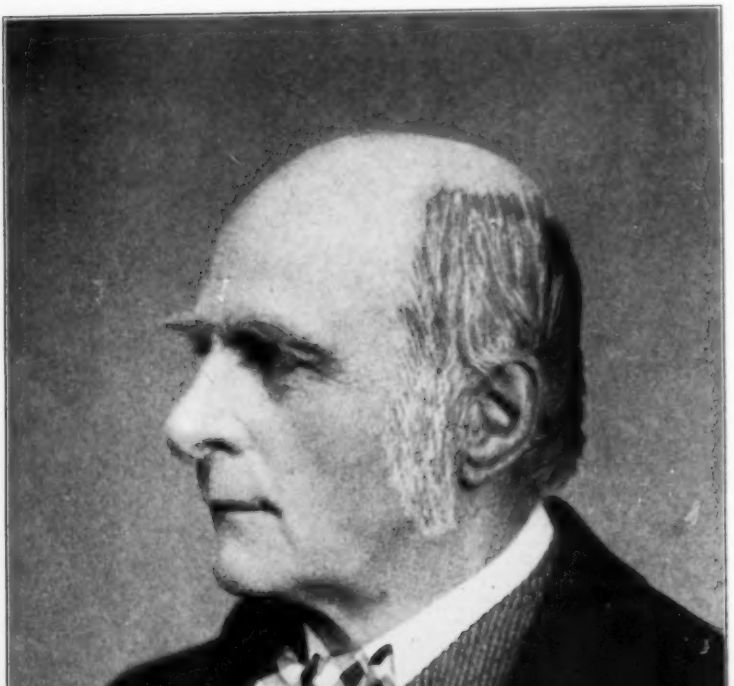
H. Hiss,

In rapid succession there were then established chairs of psychology and laboratories at Wisconsin under Professor Jastrow, at Indiana under Professor Bryan, at Nebraska under Professor Wolfe, at Brown under Professor Delabarre, at Wellesley under Professor Calkins, at Stanford under Professor Frank Angell, at Clark under Professor Sanford, at the Catholic University under Professor Pace, at Illinois under Professor Krohn, at Toronto and at Princeton under Professor Mark Baldwin. In 1891 a professorship and a laboratory were initiated at Columbia, a year later at Yale, Harvard and Cornell, Professor Münsterberg having been called from Germany to Harvard and Professor Titchener from England to Cornell. In this group should be included, for his contributions to psychology and education, John Dewey, professor of philosophy at Michigan, Minnesota, Chicago and Columbia. Josiah Royce, born in California in 1855, appointed assistant professor of philosophy at Harvard in 1882, a psychologist of distinction, alone bridges the gap between James, Hall and Ladd, our pioneers, and the second generation of American psychologists here in part enumerated.

The academic advance of psychology in America in the course of the four-year period from 1888 to 1892 is notable. There were no foundations as in Germany, England, France and Italy, in which countries a scientific psychology had for a hundred years or more been emerging from philosophy, and in which physics, physiology, zoology, neurology, psychiatry and other sciences had for an equal period been assembling subject-matter and methods that could be taken over by psychology. From our Declaration of Independence in 1776 until the founding of the Johns Hopkins University, exactly one hundred years, but little scientific research was accomplished in the United States and that little remote from psychology. There were Franklin, Rumford, Bache and Henry in physics, the Sillimans in chemistry, Gould and Chauvenet in astronomy, Peirce in mathematics, Torrey, Gray and Engelmann in botany, Agassiz, coming from overseas, Baird and Leidy in zoology, Dana, Hall, Lesley, Le Conte, Hilgard and others in geology, a practical science. But few of them have an international standing; there was none who helped to make straight the way for psychology.

The main condition favorable to the remarkable academic advance of psychology from 1883 to 1900 was the growth of our universities. Previously mental and moral philosophy had in most cases been taught by the president of the institution, qualified for both offices by being a clergyman, and when this situation changed it was natural to continue the teaching of psychology by special students of the subject. The enlargement of the universities and the adoption of the elective system permitted the introduction of a new science. Our people had curiosity, acquisitiveness and energy, with ever-increasing wealth. We were able to take over what we wanted from abroad; we were not bound by precedents and traditions. Even after years in our environment Professor Münsterberg claimed that "the presuppositions with which a science starts decide for all time the possibilities of its outer extension," and Professor Titchener said that he did not object to work on the measurement of individual differences in behavior so long as it was not called psychology. The psychologist has some reason to thank God when he is born a happy and irresponsible American child.

In comparison with literature and art, science is international. The velocity of light is the same whether measured by Fizeau in France or by Michelson in the United States. The electrons discovered by Thomson and measured by



Francis Galton

Millikan have the same hypothetical properties in Cambridge and in Chicago. The equations written by Einstein in Berlin are equally correct and equally relevant or irrelevant to the real world in Germany and in Japan. None the less the lines of advance followed by science are directed by the national life. It is not an accident that laboratory research in psychology is of German origin, that pathological psychology has been cultivated in France, that psychoanalysis has spread from Vienna, that Darwin and Galton were English, that objective psychology and the measurement of individual differences have had their chief development in the United States. Germany may keep its *Gestalt*, France its hysteries, Austria its *libido*, England its "g"; we shall continue to bear the burden of our meta-behaviorism.

America is part of the continuation of the cultural history of Europe. In psychology we owe to it everything up to the past fifty years, during which period there has been cooperation on terms that have now become equal. The two Europeans to whom our debt is the greatest are Wilhelm Wundt and Francis Galton. I had the privilege of working with both of them, as also with Herman Lotze and James Ward. Many Americans frequented the Leipzig laboratory, but perhaps only Titchener, who retained his British citizenship and outlook, continued its traditions. Stanley Hall and I were the first of Wundt's American students, but Hall worked in Ludwig's laboratory and I continued in my own rooms the work begun in America, in part because Wundt would not allow the testing in his laboratory of individuals who could not profit by introspection. Galton—the greatest man whom I have known—more nearly laid down the lines for the objective measurement of individual differences. But in his statistical methods of studying individuals he had been preceded by Quetelet and in America by Gould; in his study of imagery by Fechner, this work having been based on fallacious introspection. Wundt and Galton are the foreign psychologists whom we most honor, but it may be that if neither of them had lived psychology in America would be much what it is.

When Jefferson wrote in the Declaration of Independence that all men are created equal, he was referring to the unalienable rights to life, liberty and the pursuit of happiness. Where individual differences in rank and wealth are fixed by custom and law, they are taken as a matter of course. In a political and social democracy, such as has partly obtained in England and to a somewhat greater extent in the United States, attention is directed to the varying qualities of individuals. The wars of England are said to have been won on the playgrounds of its public schools. Competitive fellowships and scholarships, the mathematical tripos, arose in the English universities. The American college student wants to make his fraternity and the football team, sometimes also Phi Beta Kappa or Sigma Xi. Every boy may hope to become a Coolidge and get two dollars a word for his autobiography, or a Carnegie and try to make all university professors his pensioners. He learns that the race is to the swift and the battle to the strong. Those engaged at first in a conflict with nature, wild animals and savages, later in subduing the wilderness, now in the construction of a vast and complicated industrial civilization, are more likely to be interested in their own performance and in the conduct of others than to indulge in the refinements and the vagaries of introspection. It may be that there is American science and American psychology.

Of 84 Nobel prizes in science only five have been awarded in the United States, two of the recipients having been born abroad. No more were deserved.

We have not excelled in broad generalizations based on abstract considerations; but we have done more than our share in invention and in the applications of science. It is scarcely necessary to name a few from the long list of advances on which modern life is based which have had their origin or chief development here. Omitting the steamboat, the railway and other applications of steam, these include the cotton gin, the reaper and other agricultural machinery; the sewing machine, the refrigerator, the vacuum cleaner and other household machinery; the typewriter, the manifolder and other office machinery; all sorts of factory, foundry and mining machinery and methods; steel and cement construction; central heating; electric light and electric power; the telegraph, the telephone and the radio; the phonograph and the motion picture; the automobile and the airplane. It may be that trial and success methods, so important in learning by the individual, are equally fundamental in learning by the race and in the advancement of science. Who devised the Greek temple and the Gothic cathedral? The most magnificent architecture since these is here arising before our own eyes, but no one knows who is responsible for it. The proximate cause of the New York sky-scraper is an ordinance of a board of aldermen, prescribing that, in order to conserve light, high buildings must be recessed from the street.

The situation is the same in psychology. The advances in America are due to the work of uncounted individuals, many of them not known as psychologists. It appears that I was the first to publish psychological measurements of individual differences without regard to introspection and with special reference to their useful applications, but that is because I had the misfortune to be born a long time ago. So Columbia University and its Teachers College may have done the most—more than 150 members and associates of the American Psychological Association hold its doctorate—to advance objective, individual and group psychology, especially in its applications to education. In a sense this is due to Professor Thorndike, Professor Woodworth and other leaders who have worked with me, but it is in the main a manifestation of economic and other factors of our national life. Psychologists have been academic teachers and have naturally taken up problems concerned with children and schools. Other aspects of objective psychology to which these lead have been measurements of animal behavior. We are apparently somewhat behind Germany in the applications of psychology to industry, but we have a large development of industrial management and personnel work—the Taylor system is American—which will ultimately be taken over by official psychology. Even our swarms of cranks in the air above and our shoals of charlatans in the water beneath may be found to have contributed their bit, when natural selection and survival of the fit are given ample time.

It is not intended to discuss here the relative extent to which progress is due on the one side to great leaders, on the other to the activities of large numbers of individuals reacting to economic and other conditions. It seems, however, that the chief contribution of America to psychology has not been large philosophical generalizations, but the gradual accumulation from all sides of facts and methods that will ultimately create a science, both descriptive and applied, of human nature and human behavior. Each of us, as the English poet Clough says,

> must slave, a meager coral-worm,
> To build beneath the tide with excrement
> What one day will be island, or be reef,
> And will feed men, or wreck them.

THE TRIANGULATION SYSTEM OF THE UNITED STATES

By Dr. WILLIAM BOWIE

CHIEF, DIVISION OF GEODESY, U. S. COAST AND GEODETIC SURVEY

TRIANGULATION, as is well known, is a method used by surveyors and map makers to determine distances between points and to determine the geographic positions of these points over wide expanses of the earth's surface. In its simplest form, triangulation consists in the measurements with bars or metal tapes of the distance between two intervisible points. This measurement of the base is followed by the measurement of the horizontal angles of a triangle whose vertices are the two base ends and another point which may be observed from them. With one side of the triangle known and the three angles observed, one can by use of simple trigonometrical formulas derive the lengths of the other sides of the triangle.

In practice, chains of triangles are extended along a coast or in the interior of a country. The computed lengths of the sides of the triangles are, in turn, used as bases for other triangles. At intervals of fifty or one hundred miles or some other distance, depending on the character of the terrain, a new base will be measured in order to strengthen and to control the lengths computed through the chain of triangles from the first base.

Since the earth's surface is curved, consideration must be given to the dimensions of the earth in computing the latitudes and longitudes of the triangulation points. The latitudes are referred to the equator, while the longitudes are referred to the initial meridian passing through the observatory at Greenwich, England.

The first triangulation in the United States was executed in 1816 by Ferdinand Hassler, the first superintendent of the Coast Survey. The observations for this triangulation were made in the vicinity of New York. From that time till the present, triangulation has been executed by the Coast Survey (the name was changed to Coast and Geodetic Survey in 1878) until now there are 35,000 miles of arcs of triangulation extending along portions of the coasts, along the boundary between the United States and Canada and that between the United States and Mexico, and through the interior of the country.

There are several orders of triangulation used in surveying, mapping and other engineering operations, classified according to the accuracy with which angular measurements are made. The simplest measure of accuracy in triangulation is the closing error of a triangle, which is the difference between the sum of the three observed angles and 180 degrees plus the spherical excess of the triangle. Since each of the triangles, especially in first-order triangulation, covers a considerable area of the earth's surface and this surface is curved, the sum of the angles is necessarily greater than 180°.

In first-order triangulation the average closing error of a triangle is about 1″, with a maximum closing error seldom exceeding 3″. In second-order triangulation the average triangle closing error is between 1.5″ and 3″, while third-order triangulation has closing errors which average somewhat more than 5″.

The fundamental triangulation system of this country is composed of first- and second-order triangulation. It is planned to have the first-order arcs spaced at distances of approximately one hundred miles, while the intermediate areas will be crossed by arcs of second-order trian-

gulation. When the fundamental triangulation net of the country has been completed there will be few places more than about twenty-five miles from an arc of either first- or second-order work.

There are now in the United States 26,600 miles of arcs of first-order triangulation and something less than 1,000 miles of second-order work. There will be needed, to complete the net, about 48,400 miles of arcs of first- and second-order triangulation.

In the United States a plan somewhat different from that employed in many of the European countries is followed. There the total area is covered by a connected system of triangles of first order, with supplemental points classed as first and second order according to the accuracy of the observations with which they were established. We have, however, a different problem. Our area is vast, approximately 3,000,000 square miles, as compared, for instance, with the area of France which is 210,000 square miles or that of Holland which is 12,600 square miles. Our problem of covering the entire country with control triangulation is so great that it is believed to be satisfactory, both from the practical and the scientific standpoint, to have the arcs of first-order triangulation spaced at intervals of about one hundred miles, in the form of a network in order that the adjusted values may have the requisite strength. Then, as mentioned above, the intermediate areas will be crossed with arcs of second order, and the next intermediate spaces will be covered with third-order triangulation. The latter is designed to meet the immediate needs of the topographic engineers and the engineers locating the boundaries of private property, counties and states.

I wish to emphasize the great importance of triangulation in the many industrial and commercial activities of our people. We are more inclined to look on triangulation as a scientific problem and to think that the greatest benefits arise from its use in attacking certain research problems.

While the development of instruments and methods in the execution of triangulation and the computation and adjustment of the results have been real scientific problems, yet the results of the work have been of tremendous value in the practical affairs of man. The topographic map of the country, which is essential to all engineering work involving the extension of highway systems, flood control of rivers and their utilization for transportation, the development of hydroelectric power, the development of the network of telegraph and telephone lines for communication and power lines to transmit electricity, must be based on accurate geographic positions which can be determined by triangulation only. In addition, the triangulation net of the country will make it possible for the owner of each piece of property, whether city lot or farm, to have the corners of his property expressed in terms of latitudes and longitudes, and thus his boundaries are perpetuated regardless of whether or not the boundary monuments have been destroyed. There is only one place on the earth's surface which has a given latitude and longitude, and when that is known the point can be recovered at any time even if the station mark is destroyed. The saving to property owners will be great and litigation over political boundaries can be reduced to a minimum by the use of boundary surveys based on accurate triangulation.

There are many scientific uses for triangulation which alone would justify the expense involved in its execution. As is well known, one of the uses of triangulation is the determination of the figure of the earth. It is only by such work that one can determine over broken terrain the linear distances between widely separated points. When these distances are known and the astronomical latitudes and longitudes of the terminal points have been determined we have the data

which are essential in the computation of the length of an arc over the earth's surface.

Many years ago it was deemed that only meridional arcs of triangulation were needed in the determination of the figure of the earth, but in late years it has been learned that a stronger value can be obtained by the use of the arca method. The astronomical observations are affected by the configuration of that portion of the earth's surface over which the measurements are made. It is well known that mountain masses and high plateaus will deflect the plumb line or the direction of gravity to which astronomical observations are referred. Along our coasts the plumb line is deflected inland. By astronomical observations, therefore, we would have too many degrees, minutes and seconds of arc along an east and west line running across the United States. However, if we have many arcs of triangulation connected into a net with numerous astronomical stations at which the latitude and longitude have been determined by observations on the stars we are enabled to minimize the effect of the deflections of the vertical caused by topographic features.

The late Professor John F. Hayford, when he was in charge of the geodetic work of the Coast and Geodetic Survey, devised a method to test isostasy by the use of triangulation and astronomical data. He found that the topographic features did not deflect the direction of the plumb line as much as their masses would lead one to suspect. Isostasy, however, postulates that the density under elevated regions is less than normal, while under depressed regions of the earth's surface the density is greater than normal. This idea was given a quantitative test by Hayford, and it was found that the difference between the astronomical longitude and latitude of a station and geodetic latitude and longitude, obtained by triangulation methods for the same station, would be largely accounted for when isostasy was applied. We thus see that triangulation furnishes data which can be used in exploring the regions that lie below the earth's surface far beyond the reach of the deepest mines or wells. This test of isostasy made with triangulation and astronomical data has been supplemented by investigations involving values of gravity taken at hundreds of places over this and other countries. The isostatic investigations have shown that the thickness of the earth's crust is of the order of magnitude of sixty miles. The crustal material has residual rigidity, while the material below it acts as if it were plastic to long-continued stresses. The establishment of isostasy as a scientific principle will have a profound influence on the solution of many geophysical and geological problems. Thus we can see that the geophysicists and geologists have been benefited by triangulation.

The lengths in triangulation depend on measured base lines. A base line is merely the side of one of the triangles. The measurements of base lines are now made in this country with invar tapes or ribbons fifty meters in length. These tapes are standardized at the Bureau of Standards with a probable error in the derived length of not more than one part in a million. The bases are measured at least twice and with different tapes. The probable error of the actual field measurements is seldom greater than one part in two million. These probable errors lead us to believe that there are few or no base lines used in first-order triangulation in this country which have greater actual errors than one part in 300,000.

The triangulation is strengthened by the use of what are termed Laplace azimuths. A Laplace azimuth is derived from azimuth observations on Polaris, by correcting for the tilting of the meridional plane at the point of observation. The amount of this tilting is obtained from the difference of the longitudes at

the station as derived by astronomical and geodetic methods.

In the adjustment of about 13,000 miles of arcs of first-order triangulation in the western half of the United States a few years ago fifty base lines and seventy-four Laplace azimuths were used. There are sixteen closed loops in this net. The adjustment was made by a method devised by the author, which was perfected and worked out in its details by Dr. O. S. Adams, a mathematician of the Coast and Geodetic Survey.[1]

The results of this adjustment, the only one of its size ever undertaken in the world, were surprising even to the officials of the Coast and Geodetic Survey who had been engaged on geodetic work for a score or more of years. The average length of the perimeter of a circuit was 1,200 miles. The average closing error of the sixteen loops of the net in the western half of the country was one part in 450,000 of the length of the perimeter. The average correction to a section of the triangulation adjoining junction points was one part in 320,000. There were only two loop closures which were greater than one part in 200,000, and there were only four of the forty-two sections joining junction points which had corrections greater than one part in 150,000. The outside perimeter of the whole net had a length of 5,284 miles, while the closing error of this perimeter was only 33.1 feet, or one part in 842,000.

It would seem from the results of this net adjustment that distances can be measured across country with an error that is seldom greater than one part in 100,000. This statement applies to distances from a few miles up to perhaps 150 miles. With greater distances the accuracy becomes increasingly greater. This is undoubtedly due to the fact that the errors in the base and angle measurements and in the Laplace azimuths are accidental in character and their effects tend to be eliminated over great distances.

The scientific world will be glad to learn of the great accuracy with which distances can be measured by triangulation, for a very important use for geodetic work is in determining the stability of the earth's surface in both the horizontal and vertical directions. Triangulation has already been used for this purpose in this and other countries. Prior to the 1906 earthquake in California the Coast and Geodetic Survey had extended an arc of triangulation from the vicinity of San Francisco Bay southward to the Mexican border. This work was first order in accuracy, and the results were used as a base from which to make tests of the extent to which earth movements had occurred in the interval elapsing between the date of completion of the early triangulation and the time of the recent triangulation. The old triangulation stations were reoccupied and the angles reobserved during the years 1923–26. A comparison has been made of the old and the new triangulations having identical points of observations, and much has been learned as to the extent to which horizontal movements occurred in the regions covered by the investigations. There have been some decided movements with the general direction of movement to the southeastward at stations east of the San Andreas fault, while on the west side the direction of movement has been to the northwestward. It is rather remarkable that no movements were detected south of San Luis Obispo or east of triangulation stations Monticello and Vaca.[2]

The results of this comparison of the old and new triangulations in Cali-

[1] See Oscar S. Adams, "The Bowie Method of Triangulation Adjustment, as Applied to the First-order Net in the Western Part of the United States," Coast and Geodetic Survey Special Publication No. 159 (in press).

[2] See William Bowie, "Comparison of Old and New Triangulation Stations in California," U. S. Coast and Geodetic Survey Special Publication No. 151.

fornia were so encouraging that the Coast and Geodetic Survey in cooperation with the members of the advisory committee on seismology of the Carnegie Institution effected plans for making very detailed tests of the earth movements, or at least they have planned to lay the basis for such work. As a result of conferences of committee members and officials of the survey an arc of triangulation ninety miles long, extending from Newport Beach to Lucerne Valley, has been executed. The work consists of a main chain of triangles with a system of supplemental triangles. The main arc is first order in accuracy, while the angles of the supplementary triangles were observed with second-order accuracy. Along certain fault lines the stations were placed very close together in order that in the future, should an earthquake occur, detailed information might be obtained as to how far from the fault movements took place and also the directions of those movements. There were ninety-four first- and second-order stations occupied in this arc. It will be noticed that the stations are very much more closely spaced than on the arc extending from San Francisco to the Mexican border where the tests have already been made.

Additional arcs of triangulation in California will be executed across fault zones as a basis for studies of horizontal movements of the earth. The observation on these arcs will be repeated should an earthquake occur near one of them, or perhaps at intervals of five to ten years the angles will be reobserved even though no earthquake may have occurred. It is held by many that earth movements probably take place before the earthquake occurs. It will be interesting to learn whether the California triangulation will show this to be true.

The most exact piece of triangulation ever executed in the world as far as the author is aware was that for the determination of the distance between Mount Wilson and San Antonio Peak, California. The value of this distance was required by Professor A. A. Michelson in his determination of the velocity of light. Every known precaution was taken in making the measurements of the base line and the angles involved in the triangulation extending from the measured base to the line joining the two peaks. The probable error of the length of the base from field measurements alone was one part in 11,600,000, while the probable error of the computed distance between the two mountain peaks was one part in 6,800,000. Of course these probable errors must be combined with the probable errors of the standardization of the base tapes at the Bureau of Standards. The probable error of the standardization of each tape was about one part in a million and there were eight tapes used in the base measurements. The tapes were standardized both before and after the field measurements. It is not possible to know the exact error in the line joining the peaks, but it is believed that it is not greater than one part in one million. The distance furnished Professor Michelson by the director of the Coast and Geodetic Survey was 35,373.21 meters.

It seems evident from the above that the results of triangulation have important practicable and scientific uses and that the completion of the net within the next ten years or so will greatly aid the people of this country.

The geodesist has not been able alone to make the great improvements in triangulation methods and instruments during the past hundred years. He has been assisted by the mechanical engineer, the physicist and the astronomer. The combined efforts of all three have brought triangulation methods and instruments to a very high degree of perfection, but in spite of this we may look forward to other improvements in the years to come.

SIGNIFICANT DEVELOPMENTS REGARDING SOIL CORROSION

By HENRY W. HOUGH

ASSOCIATE EDITOR, *The Scientific American*

CORROSION, particularly of the ferrous metals, presents a serious industrial and economic problem. Iron is found in nature in combination with various other elements in a condition of stable equilibrium. To adapt it to our needs we extract and refine the ore, imparting to it certain qualities of usefulness. But in the process certain characteristics are developed that result in a natural tendency on the part of the metal to return to a more stable condition by the familiar process known as corrosion. For years industrial research workers and other metallurgists have been seeking practical means of overcoming this objectionable weakness of the ferrous metals, but the available "remedies" are quite impractical.

The electrochemical theory of corrosion has been accepted by most metallurgical authorities. It presents a plausible explanation of the oxidation of the ferrous metals, although certain individuals have pointed out that the theory may be said to fall short of accounting for the corrosion of copper and other metals that are below hydrogen in the electromotive series.

According to this theory, iron and steel corrode as a result of the following reaction, when water comes in contact with the surface of the metal: the water forms as hydrogen ions and hydroxide ions; the hydrogen ions are positive and dissolve an equivalent amount of iron. The dissolved iron ions then combine with the oxygen in the hydroxide ions, which are negative. The product is neutral iron oxide, and an excess of hydrogen ions which are forced out of solution and emerge as hydrogen gas.

If the corrosive action is not violent, the tiny globules of hydrogen lie along the surface of the metal in an almost invisible film, tending to retard further oxidation of the metal. If the reaction is sufficiently violent, as when the electrolyte is an acid solution, the hydrogen is evolved so rapidly that it forms bubbles which float to the surface of the solution.

One of the simplest accelerated corrosion tests is to invert a test-tube over a submerged piece of metal in a vessel filled with water or an acid solution. As the hydrogen is evolved, it accumulates in the closed end of the tube and can be measured easily. It is presumed that the amount of hydrogen evolved during the reaction is directly proportionate to the amount of metal consumed, and that the rate at which the hydrogen is evolved is the equivalent of the rate of corrosion.

Within the past few years the study of soil corrosion has advanced materially as a result of several well-planned developments. Of these, the most significant are: (1) The U. S. Bureau of Standards studies regarding the effect of corrosion on various metals buried in various locations throughout the country, in soils classified according to physical characteristics; (2) the research of Dr. H. D. Holler, supplementing the work of the Bureau of Standards, regarding the effect of certain factors in soils which govern their corrosiveness; (3) the development of a method by which representative soil samples are analyzed and given corrosion ratings according to inherent chemical and physical characteristics, and the develop-

EFFECT OF CORROSION

ON SAMPLES OF THE SAME METAL BURIED IN DIFFERENT SOILS AND DIFFERENT METALS BURIED IN ONE LOCATION, SHOWING THAT SOIL CHARACTERISTICS CONTROL THE NATURE AND EXTENT OF CORROSION.

TYPICAL TOPOGRAPHICAL SITUATION

ALONG THE RIGHT-OF-WAY OF A LONG NATURAL-GAS PIPELINE, SHOWING SURFACE CHARACTERISTICS WHICH MUST BE TAKEN INTO CONSIDERATION WHEN PREDETERMINING THE INTENSITY OF CORROSION.

CORROSION MUST BE ANTICIPATED

AND GUARDED AGAINST TO PREVENT UNTIMELY DESTRUCTION OF IMPORTANT PIPELINES, SUCH AS THIS ONE WHICH NOW SUPPLIES MEMPHIS, TENNESSEE, WITH GAS FROM LOUISIANA.

THESE NATURAL-GAS PIPELINES

AT A MISSISSIPPI RIVER CROSSING ARE BEING COATED WITH A THICK LAYER OF ENAMEL, WHICH WILL PROTECT THE METAL FROM CORROSION.

ment of an adaptable system for balancing these ratings with relevant surface characteristics in any given location, for the purpose of determining the relative intensity of corrosion to be expected in various areas.

The investigation of the Bureau of Standards was begun in 1922, with the Bureau of Soils and a number of pipe and coating manufacturers cooperating. Samples of various metals, both protected and unprotected, were buried in test pits located in about forty cities representing different sections of the country. The samples removed after two- and four-year periods were described in the bureau's Technologic Paper No. 368, and more recent data now available will give complete information regarding the manner in which the soils were classified, the materials used in the tests and conclusions drawn after making a study of the specimens removed.

A number of significant observations were made by Mr. K. H. Logan and his associate in the paper mentioned above. A few of these will be mentioned here.

> Both the 1924 and 1926 specimens indicate that the type of corrosion is in some way associated with the locality in which the specimens are buried. It has been assumed that the effects found are due to some characteristics of the soil of the locality. Serious corrosion has been observed in several localities . . . attention should also be called to the fact that in a majority of soils the rate of corrosion is low, and in some it is practically negligible.

Referring to the comparative merits of the various metals tested, the authors of the paper said:

> While no one material that is suitable for general use for pipelines now appears to be superior to all others in all soils, there is an indication that a saving can be effected by the proper selection of a pipe material with respect to soil conditions.

It is understood by all parties interested that the relative length of life of such materials as steel and wrought iron can not be estimated accurately until the specimens have been exposed to corrosive action for several more years.

TAKING SOIL SAMPLES

ON THE RIGHT-OF-WAY FOR A PROPOSED PIPE-LINE, PREPARATORY TO DETERMINING THE POTENTIAL CORROSIVENESS AT VARIOUS POINTS.

Although most of the paints and other protective coatings applied to the samples were too thin to give reliable com-

THE EXTRACTED DIRT IS ROLLED

AND QUARTERED DOWN AS IN MINE SAMPLING IN ORDER TO ASSURE A REPRESENTATIVE SAMPLE OF THE SOIL TO BE TESTED.

parisons of their value, it was determined that

> a coating satisfactory for one soil may not be satisfactory for another, and in order to use data on protective coatings tested in one locality for predicting results to be obtained in another locality, soil conditions must be studied.

While engaged in studies concerning these samples, Mr. Logan had noticed the presence of galvanic currents along a pipeline situated at a considerable distance from any known power source. In certain locations or in certain soils the currents flowed from the soil to the pipe, while in nearby locations the current was found to be flowing from the pipe to the soil. Although the importance of such currents with respect to corrosiveness is not well understood, it was believed that they might be interpreted as evidence of the electrochemical nature of soil corrosion.

Dr. H. D. Holler has substantiated the theory that the rate of corrosion is proportionate to the rate at which hydrogen is produced and removed from the surface of iron or steel. This is in accordance with the equations (Whitney):

$$Fe + 2H^{+} = Fe^{++} + 2H,$$

or

$$Fe + 2H_2O = Fe(OH_2) + H_2.$$

In the studies conducted by the Bureau of Standards, the investigators were handicapped by insufficient data concerning the soils in which metal specimens have been buried. It was found that the classification of soils according to texture and other physical characteristics was misleading and of no value in appraising their potential corrosiveness. No data were obtained to show the amount of moisture in the various test pits. Water, of course, is the most important factor in corrosion; it provides the all-important hydrogen, dissolves soluble salts and other potentially active ingredients in the soil and regulates both the rate and duration of the corrosive action.

Appreciating the need for more adequate knowledge about the corrosive characteristics of soils, an engineer and a chemist collaborated in developing a practical method for determining the relative intensity of corrosiveness in any prescribed area. This method, orig-

inated and developed by Mr. P. J. Richards and Mr. William Thompson Smith, is known as a soil corrosion survey.

When making a corrosion survey of the right-of-way for a pipeline several hundred miles in length, the following procedure is used. Samples of the soil are taken, at intervals of not more than one mile and at the depth at which the pipe will rest when in service. A topographical survey is made, noting the amount of moisture, degree and direction of slope, vegetation and both present and probable use of the surface of the land. Rainfall records and local weather conditions are taken into consideration.

The samples are marked, shipped to the laboratory and classified according to location. The moisture content is determined by weighing, air-drying and reweighing a portion of the soil in each air-tight container. A solution is then made, by mixing a portion of each sample with distilled water, to determine by analyses the content of various water-soluble salts. Analyses of the soil as received are made also, because of the possibility that certain chemicals present may become soluble later, although insoluble in water in their present state.

The pH value, or active acidity, of each solution is determined by the La-Motte method. Since the active acidity of a solution is usually only a part of its total acidity, which is determined by titration, too much reliance can not be placed on the pH value alone. Never-

HUNDREDS OF SOIL SAMPLES

WHICH HAVE BEEN SUBJECTED TO A COMPREHENSIVE SERIES OF CHEMICAL, PHYSICAL AND ACCELERATED CORROSION TESTS TO DETERMINE THEIR RELATIVE CORROSIVENESS.

TESTING FOR ACTIVE ACIDITY, OR pH VALUE

SOLUTIONS MADE FROM REPRESENTATIVE SOIL SAMPLES; THE TOTAL ACIDITY IS DETERMINED BY TITRATION.

theless, the determination of the pH is highly important in appraising the potential corrosiveness in soils.

With this accumulation of analytical data and the facts obtained from the topographical survey the next step is to correlate the various factors at each location in order that each sample can be given a relative corrosion rating. It is one thing to "analyze" soils, and quite another to interpret the final results in terms of relative corrosiveness. The relative proportion of soluble salts, the amount of moisture, the drainage situation, the active acidity and total acidity and other accelerating or inhibiting factors are balanced and evaluated in what has been found to be their proper relation to each other and to all other known factors.

It may be well to quote Mr. Richards, who directs laboratory and field work in connection with the surveys, concerning this phase of the procedure.

> We have found that neither a chemical analysis of soils, nor a topographical survey, will give information of sufficient value to determine the probable corrosion to the pipe. Both must be completed and considered together and as a whole, before a reasonably accurate estimate can be made.

Surveys made in the west have substantiated the opinion of Dr. Holler that in arid regions (such as the eastern watershed of the Rocky Mountains, where large areas are arid or semiarid) soil corrosion is dependent on the soluble salt content of the soil. In Mississippi, Alabama and Georgia the corrosion surveys have shown that the total acidity is

usually the predominating factor. In general, the soils of the east are acid and those of the west are alkaline; in any locality, however, a high percentage of alkalis will tend to neutralize an acid soil, and *vice versa*. When possible, control samples of known corrosiveness are analyzed, to learn what factors have influenced corrosion in the locality, under field conditions.

With the cooperation of the Bureau of Standards, soil samples from about thirty-five of the test pits were analyzed at the Richards laboratory, in accordance with the method used on commercial surveys. The samples were dry when received at the laboratory, rather than in the customary air-tight containers, making it impossible to gauge the moisture content of the soils. However, the usual analyses were made, the results

THE GREAT VARIETY OF THE TOPOGRAPHICAL CONDITIONS

ENCOUNTERED BY ENGINEERS IN CONSTRUCTING LONG-DISTANCE OIL AND GAS PIPELINES; THE CORROSION SURVEY SOMETIMES REVEALS DANGEROUSLY CORROSIVE AREAS IN LOCATIONS THAT WOULD APPEAR TO BE QUITE SAFE FROM SEVERE CORROSION

were correlated and each sample was given a corrosion rating.

These ratings were then checked against the actual corrosion record of the soils, which had been measured and tabulated by the Bureau of Standards after the metal specimens had been removed from the pits. Despite the fact that no data had been available to show the amount of moisture in the soils, the analytical ratings checked the actual corrosion record to such a degree as to leave little doubt as to the reliability of the method.

When corrosion surveys are made in other places, the procedure is altered to meet any local situation. In the city of Pueblo, Colorado, corrosion is extremely severe in the north and east sections, but in the southern part there are practically no corrosion leaks in piping. The corrosive soil contains relatively large amounts of calcium and magnesium sulphates, and is principally clay, which accelerates corrosion because it holds moisture. In the other soil, there are very small proportions of sulphur, sulphates and chlorides, and instead of gypsum the soil is sandy and well drained. Here, as in other places, it has been possible to ascertain the governing corrosive factors and chart the different areas.

To summarize, the Bureau of Standards has contributed valuable data as to the effects of corrosion on various metals buried in different locations, showing that the inherent characteristics of the soil are the dominating factors influencing corrosion. Dr. Holler has confirmed the theory that the rate of corrosiveness is proportionate to the rate at which hydrogen is evolved and removed from the surface of the metal. In addition to these developments, there has been significant progress in working out a practical method for appraising and charting the relative intensity of soil corrosion in various locations by making a complete corrosion survey of all local factors.

While it is obviously impossible to mention all the important developments produced by recent soil corrosion research, these outstanding accomplishments will serve to show the significant trends and their effect in ameliorating the ever-present corrosion problem.

THE PROBLEM OF THE WILDERNESS

By ROBERT MARSHALL

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I

IT is appalling to reflect how much useless energy has been expended in arguments which would have been inconceivable had the terminology been defined. In order to avoid such futile controversy I shall undertake at the start to delimit the meaning of the principal term with which this paper is concerned. According to Dr. Johnson a *wilderness* is "a tract of solitude and savageness," a definition more poetic than explicit. Modern lexicographers do better with "a tract of land, whether a forest or a wide barren plain, uncultivated and uninhabited by human beings."[1] This definition gives a rather good foundation, but it still leaves a penumbra of partially shaded connotation.

For the ensuing discussion I shall use the word *wilderness* to denote a region which contains no permanent inhabitants, possesses no possibility of conveyance by any mechanical means and is sufficiently spacious that a person in crossing it must have the experience of sleeping out. The dominant attributes of such an area are: first, that it requires any one who exists in it to depend exclusively on his own effort for survival; and second, that it preserves as nearly as possible the primitive environment. This means that all roads, power transportation and settlements are barred. But trails and temporary shelters, which were common long before the advent of the white race, are entirely permissible.

When Columbus effected his immortal debarkation, he touched upon a wilderness which embraced virtually a hemisphere. The philosophy that progress is proportional to the amount of alteration imposed upon nature never seemed to have occurred to the Indians. Even such tribes as the Incas, Aztecs and Pueblos made few changes in the environment in which they were born. "The land and all that it bore they treated with consideration; not attempting to improve it, they never desecrated it."[2] Consequently, over billions of acres the aboriginal wanderers still spun out their peripatetic careers, the wild animals still browsed in unmolested meadows and the forests still grew and moldered and grew again precisely as they had done for undeterminable centuries.

It was not until the settlement of Jamestown in 1607 that there appeared the germ for that unabated disruption of natural conditions which has characterized all subsequent American history. At first expansion was very slow. The most intrepid seldom advanced further from their neighbors than the next drainage. At the time of the Revolution the zone of civilization was still practically confined to a narrow belt lying between the Atlantic Ocean and the Appalachian valleys. But a quarter of a century later, when the Louisiana Purchase was consummated, the outposts of civilization had reached the Mississippi, and there were foci of colonization in half a dozen localities west of the Appalachians, though the unbroken line of the frontier was east of the mountains.[3]

It was yet possible as recently as 1804 and 1805 for the Lewis and Clark Expedition to cross two thirds of a continent without seeing any culture more ad-

[1] Webster's New International Dictionary.

[2] Willa Cather, "Death Comes for the Archbishop."

[3] Frederic L. Paxson, "History of the American Frontier."

vanced than that of the Middle Stone Age. The only routes of travel were the uncharted rivers and the almost impassable Indian trails. And continually the expedition was breaking upon some "truly magnificent and sublimely grand object, which has from the commencement of time been concealed from the view of civilized man."[4]

This exploration inaugurated a century of constantly accelerating emigration such as the world had never known. Throughout this frenzied period the only serious thought ever devoted to the wilderness was how it might be demolished. To the pioneers pushing westward it was an enemy of diabolical cruelty and danger, standing as the great obstacle to industry and development. Since these seemed to constitute the essentials for felicity, the obvious step was to excoriate the devil which interfered. And so the path of empire proceeded to substitute for the undisturbed seclusion of nature the conquering accomplishments of man. Highways wound up valleys which had known only the footsteps of the wild animals; neatly planted gardens and orchards replaced the tangled confusion of the primeval forest; factories belched up great clouds of smoke where for centuries trees had transpired toward the sky, and the ground-cover of fresh sorrel and twinflower was transformed to asphalt spotted with chewing-gum, coal dust and gasoline.

To-day there remain less than twenty wilderness areas of a million acres, and annually even these shrunken remnants of an undefiled continent are being despoiled. Aldo Leopold has truly said:

> The day is almost upon us when canoe travel will consist in paddling up the noisy wake of a motor launch and portaging through the back yard of a summer cottage. When that day comes canoe travel will be dead, and dead too will be a part of our Americanism. . . . The day is almost upon us when a pack train must wind its way up a graveled highway and turn out its bell mare in the pasture of a summer hotel. When that day comes the pack train will be dead, the diamond hitch will be merely a rope and Kit Carson and Jim Bridger will be names in a history lesson.[5]

Within the next few years the fate of the wilderness must be decided. This is a problem to be settled by deliberate rationality and not by personal prejudice. Fundamentally, the question is one of balancing the total happiness which will be obtainable if the few undesecrated areas are perpetuated against that which will prevail if they are destroyed. For this purpose it will be necessary: first, to consider the extraordinary benefits of the wilderness; second, to enumerate the drawbacks to undeveloped areas; third, to evaluate the relative importance of these conflicting factors, and finally, to formulate a plan of action.

II

The benefits which accrue from the wilderness may be separated into three broad divisions: the physical, the mental and the esthetic.

Most obvious in the first category is the contribution which the wilderness makes to health. This involves something more than pure air and quiet, which are also attainable in almost any rural situation. But toting a fifty-pound pack over an abominable trail, snowshoeing across a blizzard-swept plateau or scaling some jagged pinnacle which juts far above timber all develop a body distinguished by a soundness, stamina and élan unknown amid normal surroundings.

[4] Reuben G. Thwaites, "Original Journals of the Lewis and Clark Expedition, 1804–1806," June 13, 1805.

[5] Aldo Leopold, "The Last Stand of the Wilderness," *American Forests and Forest Life*, October, 1925.

More than mere heartiness is the character of physical independence which can be nurtured only away from the coddling of civilization. In a true wilderness if a person is not qualified to satisfy all the requirements of existence, then he is bound to perish. As long as we prize individuality and competence it is imperative to provide the opportunity for complete self-sufficiency. This is inconceivable under the effete superstructure of urbanity; it demands the harsh environment of untrammeled expanses.

Closely allied is the longing for physical exploration which bursts through all the chains with which society fetters it. Thus we find Lindbergh, Amundsen, Byrd gaily daring the unknown, partly to increase knowledge, but largely to satisfy the craving for adventure. Adventure, whether physical or mental, implies breaking into unpenetrated ground, venturing beyond the boundary of normal aptitude, extending oneself to the limit of capacity, courageously facing peril. Life without the chance for such exertions would be for many persons a dreary game, scarcely bearable in its horrible banality.

It is true that certain people of great erudition "come inevitably to feel that if life has any value at all, then that value comes in thought,"[6] and so they regard mere physical pleasures as puerile inconsequences. But there are others, perfectly capable of comprehending relativity and the quantum theory, who find equal ecstacy in non-intellectual adventure. It is entirely irrelevant which view-point is correct; each is applicable to whoever entertains it. The important consideration is that both groups are entitled to indulge their penchant, and in the second instance this is scarcely possible without the freedom of the wilderness.

[6] Joseph Wood Krutch, "The Modern Temper."

III

One of the greatest advantages of the wilderness is its incentive to independent cogitation. This is partly a reflection of physical stimulation, but more inherently due to the fact that original ideas require an objectivity and perspective seldom possible in the distracting propinquity of one's fellow men. It is necessary to "have gone behind the world of humanity, seen its institutions like toadstools by the wayside."[7] This theorizing is justified empirically by the number of America's most virile minds, including Thomas Jefferson, Henry Thoreau, Louis Agassiz, Herman Melville, Mark Twain, John Muir and William James, who have felt the compulsion of periodical retirements into the solitudes. Withdrawn from the contaminating notions of their neighbors, these thinkers have been able to meditate, unprejudiced by the immuring civilization.

Another mental value of an opposite sort is concerned not with incitement but with repose. In a civilization which requires most lives to be passed amid inordinate dissonance, pressure and intrusion, the chance of retiring now and then to the quietude and privacy of sylvan haunts becomes for some people a psychic necessity. It is only the possibility of convalescing in the wilderness which saves them from being destroyed by the terrible neural tension of modern existence.

There is also a psychological bearing of the wilderness which affects, in contrast to the minority who find it indispensable for relaxation, the whole of human kind. One of the most profound discoveries of psychology has been the demonstration of the terrific harm caused by suppressed desires. To most of mankind a very powerful desire is the appetite for adventure. But in an age of

[7] Henry David Thoreau, "Journals," April 2, 1852.

machinery only the extremely fortunate have any occasion to satiate this hankering, except vicariously. As a result people become so choked by the monotony of their lives that they are readily amenable to the suggestion of any lurid diversion. Especially in battle, they imagine, will be found the glorious romance of futile dreams. And so they endorse war with enthusiasm and march away to stirring music, only to find their adventure a chimera, and the whole world miserable. It is all tragically ridiculous, and yet there is a passion there which can not be dismissed with a contemptuous reference to childish quixotism. William James has said that "militarism is the great preserver of ideals of hardihood, and human life with no use for hardihood would be contemptible."[8] The problem, as he points out, is to find a "moral equivalent of war," a peaceful stimulation for the hardihood and competence instigated in bloodshed. This equivalent may be realized if we make available to every one the harmless excitement of the wilderness. Bertrand Russell has skilfully amplified this idea in his essay on "Machines and the Emotions." He expresses the significant conclusion that "many men would cease to desire war if they had opportunities to risk their lives in Alpine climbing."[9]

IV

In examining the esthetic importance of the wilderness I will not engage in the unprofitable task of evaluating the preciousness of different sorts of beauty, as, for instance, whether an aeronical view over the Grand Canyon is worth more than the Apollo of Praxiteles. For such a rating would always have to be based on a subjective standard, whereas the essential for any measure is impersonality. Instead of such useless metaphysics I shall call attention to several respects in which the undisputed beauty of the primeval, whatever its relative merit, is distinctly unique.

Of the myriad manifestations of beauty, only natural phenomena like the wilderness are detached from all temporal relationship. All the beauties in the creation or alteration of which man has played even the slightest rôle are firmly anchored in the historic stream. They are temples of Egypt, oratory of Rome, painting of the Renaissance or music of the Classicists. But in the wild places nothing is moored more closely than to geologic ages. The silent wanderer crawling up the rocky shore of the turbulent river could be a savage from some prehistoric epoch or a fugitive from twentieth century mechanization.

The sheer stupendousness of the wilderness gives it a quality of intangibility which is unknown in ordinary manifestations of ocular beauty. These are always very definite two or three dimensional objects which can be physically grasped and circumscribed in a few moments. But "the beauty that shimmers in the yellow afternoons of October, who ever could clutch it."[10] Any one who has looked across a ghostly valley at midnight, when moonlight makes a formless silver unity out of the drifting fog, knows how impossible it often is in nature to distinguish mass from hallucination. Any one who has stood upon a lofty summit and gazed over an inchoate tangle of deep canyons and cragged mountains, of sunlit lakelets and black expanses of forest, has become aware of a certain giddy sensation that there are no distances, no measures, simply unrelated matter rising and falling without any analogy to the banal geometry of breadth, thickness and height. A fourth dimension of immensity is added which makes the location of some dim elevation outlined against the sunset as incom-

[8] William James, "The Moral Equivalent of War."

[9] Bertrand Russell, "Essays in Scepticism."

[10] Ralph Waldo Emerson, "Nature."

mensurable to the figures of the topographer as life itself is to the quantitative table of elements which the analytic chemist proclaims to constitute vitality.

Because of its size the wilderness also has a physical ambiency about it which most forms of beauty lack. One looks from outside at works of art and architecture, listens from outside to music or poetry. But when one looks at and listens to the wilderness he is encompassed by his experience of beauty, lives in the midst of his esthetic universe.

A fourth peculiarity about the wilderness is that it exhibits a dynamic beauty. A Beethoven symphony or a Shakespearean drama, a landscape by Corot or a Gothic cathedral, once they are finished become virtually static. But the wilderness is in constant flux. A seed germinates, and a stunted seedling battles for decades against the dense shade of the virgin forest. Then some ancient tree blows down and the long-suppressed plant suddenly enters into the full vigor of delayed youth, grows rapidly from sapling to maturity, declines into the conky senility of many centuries, dropping millions of seeds to start a new forest upon the rotting débris of its own ancestors, and eventually topples over to admit the sunlight which ripens another woodland generation.

Another singular aspect of the wilderness is that it gratifies every one of the senses. There is unanimity in venerating the sights and sounds of the forest. But what are generally esteemed to be the minor senses should not be slighted. No one who has ever strolled in springtime through seas of blooming violets, or lain at night on boughs of fresh balsam, or walked across dank holms in early morning can omit odor from the joys of the primordial environment. No one who has felt the stiff wind of mountaintops or the softness of untrodden sphagnum will forget the exhilaration experienced through touch. "Nothing ever tastes as good as when it's cooked in the woods" is a trite tribute to another sense. Even equilibrium causes a blithe exultation during many a river crossing on tenuous foot log and many a perilous conquest of precipice.

Finally, it is well to reflect that the wilderness furnishes perhaps the best opportunity for pure esthetic enjoyment. This requires that beauty be observed as a unity, and that for the brief duration of any pure esthetic experience the cognition of the observed object must completely fill the spectator's cosmos. There can be no extraneous thoughts—no question about the creator of the phenomenon, its structure, what it resembles or what vanity in the beholder it gratifies. "The purely esthetic observer has for the moment forgotten his own soul";[11] he has only one sensation left and that is exquisiteness. In the wilderness, with its entire freedom from the manifestations of human will, that perfect objectivity which is essential for pure esthetic rapture can probably be achieved more readily than among any other forms of beauty.

V

But the problem is not all one-sided. Having discussed the tremendous benefits of the wilderness, it is now proper to ponder upon the disadvantages which uninhabited territory entails.

In the first place, there is the immoderate danger that a wilderness without developments for fire protection will sooner or later go up in smoke and down in ashes.

A second drawback is concerned with the direct economic loss. By locking up wilderness areas we as much as remove from the earth all the lumber, minerals, range land, water-power and agricultural possibilities which they contain. In the face of the tremendous demand

[11] Irwin Edman, "The World, the Arts and the Artist."

for these resources it seems unpardonable to many to render nugatory this potential material wealth.

A third difficulty inherent in undeveloped districts is that they automatically preclude the bulk of the population from enjoying them. For it is admitted that at present only a minority of the genus *Homo* cares for wilderness recreation, and only a fraction of this minority possesses the requisite virility for the indulgence of this desire. Far more people can enjoy the woods by automobile. Far more would prefer to spend their vacations in luxurious summer hotels set on well-groomed lawns than in leaky, fly-infested shelters bundled away in the brush. Why then should this majority have to give up its rights?

VI

As a result of these last considerations the irreplaceable values of the wilderness are generally ignored, and a fatalistic attitude is adopted in regard to the ultimate disappearance of all unmolested localities. It is my contention that this outlook is entirely unjustified, and that almost all the disadvantages of the wilderness can be minimized by forethought and some compromise.

The problem of protection dictates the elimination of undeveloped areas of great fire hazard. Furthermore, certain infringements on the concept of an unsullied wilderness will be unavoidable in almost all instances. Trails, telephone lines and lookout cabins will have to be constructed, for without such precaution most forests in the west would be gutted. But even with these improvements the basic primitive quality still exists: dependence on personal effort for survival.

Economic loss could be greatly reduced by reserving inaccessible and unproductive terrain. Inasmuch as most of the highly valuable lands have already been exploited, it should be easy to confine a great share of the wilderness tracts to those lofty mountain regions where the possibility of material profit is unimportant. Under these circumstances it seems like the grossest illogicality for any one to object to the withdrawal of a few million acres of low-grade timber for recreational purposes when one hundred million acres of potential forest lie devastated.[12] If one tenth portion of this denuded land were put to its maximum productivity, it could grow more wood than all the proposed wilderness areas put together. Or if our forests, instead of attaining only 22 per cent. of their possible production,[13] were made to yield up to capacity, we could refrain from using three quarters of the timber in the country and still be better off than we are to-day. The way to meet our commercial demands is not to thwart legitimate divertisement, but to eliminate the unmitigated evils of fire and destructive logging. It is time we appreciated that the real economic problem is to see how little land need be employed for timber production, so that the remainder of the forest may be devoted to those other vital uses incompatible with industrial exploitation.

Even if there should be an underproduction of timber, it is well to recall that it is much cheaper to import lumber for industry than to export people for pastime. The freight rate from Siberia is not nearly as high as the passenger rate to Switzerland.

What small financial loss ultimately results from the establishment of wilderness areas must be accepted as a fair price to pay for their unassessable preciousness. We spend about twenty-one billion dollars a year for entertainment of all sorts.[14] Compared with this there

[12] George P. Ahern, "Deforested America," Washington, D. C.

[13] U. S. Department of Agriculture, "Timber, Mine or Crop?"

[14] Stuart Chase, "Whither Mankind?"

is no significance to the forfeiture of a couple of million dollars of annual income, which is all that our maximum wilderness requirements would involve. Think what an enormously greater sum New York City alone sacrifices in the maintenance of Central Park.

But the automobilists argue that a wilderness domain precludes the huge majority of recreation-seekers from deriving any amusement whatever from it. This is almost as irrational as contending that because more people enjoy bathing than art exhibits therefore we should change our picture galleries into swimming pools. It is undeniable that the automobilist has more roads than he can cover in a lifetime. There are upward of 3,000,000[15] miles of public highways in the United States, traversing many of the finest scenic features in the nation. Nor would the votaries of the wilderness object to the construction of as many more miles in the vicinity of the old roads, where they would not be molesting the few remaining vestiges of the primeval. But when the motorists also demand for their particular diversion the insignificant wilderness residue, it makes even a Midas appear philanthropic.

> Such are the differences among human beings in their sources of pleasure, that unless there is a corresponding diversity in their modes of life, they neither obtain their fair share of happiness, nor grow up to the mental, moral and esthetic stature of which their nature is capable. Why then should tolerance extend only to tastes and modes of life which extort acquiescence by the multitude of their adherents?[16]

It is of the utmost importance to concede the right of happiness also to people who find their delight in unaccustomed ways. This prerogative is valid even though its exercise may encroach slightly on the fun of the majority, for there is a point where an increase in the joy of the many causes a decrease in the joy of the few out of all proportion to the gain of the former. This has been fully recognized not only by such philosophers of democracy as Paine, Jefferson and Mill, but also in the practical administration of governments which spend prodigious sums of money to satisfy the expensive wants of only a fragment of the community. Public funds which could bring small additional happiness to the mobility are diverted to support museums, art galleries, concerts, botanical gardens, menageries and golf-links. While these, like wilderness areas, are open to the use of every one, they are vital to only a fraction of the entire population. Nevertheless, they are almost universally approved, and the appropriations to maintain them are growing phenomenally.

[15] "The World Almanac," 1929.

[16] John Stuart Mill, "On Liberty."

VII

These steps of reasoning lead up to the conclusion that the preservation of a few samples of undeveloped territory is one of the most clamant issues before us today. Just a few years more of hesitation and the only trace of that wilderness which has exerted such a fundamental influence in molding American character will lie in the musty pages of pioneer books and the mumbled memories of tottering antiquarians. To avoid this catastrophe demands immediate action.

A step in the right direction has already been initiated by the National Conference on Outdoor Recreation,[17] which has proposed twenty-one possible wilderness areas. Several of these have already been set aside in a tentative way by the Forest Service; others are undergoing more careful scrutiny. But this only represents the incipiency of what ought to be done.

[17] National Conference on Outdoor Recreation, "Recreation Resources of Federal Lands," Washington, D. C.

A thorough study should forthwith be undertaken to determine the probable wilderness needs of the country. Of course, no precise reckoning could be attempted, but a radical calculation would be feasible. It ought to be radical for three reasons: because it is easy to convert a natural area to industrial or motor usage, impossible to do the reverse; because the population which covets wilderness recreation is rapidly enlarging and because the higher standard of living which may be anticipated should give millions the economic power to gratify what is to-day merely a pathetic yearning. Once the estimate is formulated, immediate steps should be taken to establish enough tracts to insure every one who hungers for it a generous opportunity of enjoying wilderness isolation.

To carry out this program it is exigent that all friends of the wilderness ideal should unite. If they do not present the urgency of their view-point the other side will certainly capture popular support. Then it will only be a few years until the last escape from society will be barricaded. If that day arrives there will be countless souls born to live in strangulation, countless human beings who will be crushed under the artificial edifice raised by man. There is just one hope of repulsing the tyrannical ambition of civilization to conquer every niche on the whole earth. That hope is the organization of spirited people who will fight for the freedom of the wilderness.

ON TO THE CITY, FARMER!

By T. SWANN HARDING

MOUNT RAINIER, MARYLAND

HEYWOOD BROUN, in one of his rather frequently vouchsafed moments of inspiration, remarked not long ago that the American farmer was a man who arose at five o'clock in the morning in order to produce more wheat than he could possibly sell so as to get poorer each year. As a remedy for this grave situation he suggested that farmers meet in solemn conclave, agree unanimously to lie in bed till ten o'clock each morning and thus cut wheat production to the point where a high price level could be maintained. If Broun was seeking to play fool at that time it must be remarked that the fool in his folly sometimes knoweth wisdom.

We have in America evolved a tremendous machine designed to emphasize a back-to-the-farm movement and, at the same time, to make agriculture vastly more efficient. From the president down this back-to-the-farm gospel has been hammered into us for generations—the idea that our national prosperity is built upon a sturdy yeomanry or peasantry and that the trend to the cities will ultimately be the death of us as a great self-sustaining organization. In spite of these high-pressure endeavors on the part of statesmen, scientists, economists, social reformers, educators and the press it is conservatively estimated that only about one eighth, or 800,000, of our 6,500,000 farmers have actually taken advantage of the best scientific methods and the most up-to-date agricultural machinery available.

The American farmer remains predominantly inefficient and teeters chronically on the brink of destitution and ruin. In spite of this fact one of his greatest difficulties is undeniably over-production! To-day the Farm Board "believes that it can be of great assistance to the American farmers by encouraging the development of large-scale, central cooperative organizations." Already 2,000,000 farmers, or nearly one third of the total, belong to the 12,500 existing cooperative associations. It nevertheless remains a fact that this—whether it eventuate in cooperative marketing or more efficiently organized productive methods—will inevitably stimulate production and compel the American farmer to arise still later in the morning to prevent a disastrous depression of price levels. Even as things are, the slightest overemphasis by Department of Agriculture authorities can at any time create dangerous gluts of various farm products and subsequent heavy losses.

Let us examine this problem a little more in detail, adducing in the process a few stray bits of informative evidence. A recent U. S. Department of Agriculture circular addressed itself to the problem of the "Farm Real Estate Situation." It noted, in 1928, a general decline to four fifths of the pre-war value, all economic factors considered. The actual purchasing power of farm products was 93 to 95 per cent. of the pre-war value, whereas the taxes on farm real estate rose to 258 per cent. of the pre-war level in 1927 as against 253 per cent. and 250 per cent. in 1926 and 1925 respectively. It was shown that values have fallen faster than earnings; that the multitude of foreclosed and "distressed" farms still further depressed values, and that, in summary, while the composite farm price of thirty major products was one third above pre-war level, taxes stood at 2½ times pre-war level, machin-

ery was twice as costly and building materials and wages of farm labor were two thirds above pre-war level. The farmer's acute economic predicament becomes apparent.

On top of this the farmer does not know his production costs or how far behind he gets anyway, according to Dean Robert Stewart, of the University of Nevada School of Agriculture. In 1919, for instance, the cost of wheat production was studied by the Department of Agriculture in the states of Kansas, Missouri, Nebraska, Minnesota, North Dakota and South Dakota, and although the cost for winter wheat averaged $1.87 per bushel to produce, the range was from $1 to $8.20 a bushel! The spring wheat average was $2.65 per bushel and the range $1.10 to $14.40. What was a fair, actual, scientific cost of production? Who knows?

In December, 1928, O. E. Reed, chief of the Bureau of Dairy Industry, remarked that a cow producing 100 pounds of butter-fat per year returned only $14 to the farmer over its cost to keep, while if it produced 500 pounds of butter-fat it would give as good an income as thirteen low-grade animals, or $178. One good cow will, therefore, supply 500 pounds of butter-fat for market, but thirteen cows which yield a total of only 1,300 pounds of butter-fat annually, at the same money income value, continue to be kept on many farms and inefficiently produce surpluses with potentialities of economic unbalance. This is further evidence of farm inefficiency.

In June, 1929, C. W. Larson, former chief of the Bureau of Dairy Industry, was quoted in the *Monthly Labor Review* of the Department of Labor as saying that cows producing 9,000 pounds of milk annually, which is twice the average production for the country—in spite of the fact that really good cows to-day produce from 27,000 to 35,000 pounds—eat only 40 per cent. more than animals which produce but 4,500 pounds annually. The average life of a dairy cow is seven years. From 1921 to 1927 our milk consumption increased 30,000,000,000 pounds; this would have required an increased cow population of 6,000,000, yet our cow census on January 1, 1927, showed but 21,948,000 such animals, or an increase of only 160,000 over the 1921 figures, a saving of 5,840,000 cows. This both illustrates present-day farming inefficiency and gives an inkling of what might be expected if efficiency ruled. For if the milk production of the average cow increased but 100 pounds annually, we could continue to supply a two-million increase in our human population with milk for forty years without increasing the number of our dairy cattle, and we should then have raised average production only to the point of 8,500 pounds per animal, which is one third or one fourth of the annual production of the best animals now living.

Again, in the *Nation's Business* for June, 1929, Charles H. Leber, an ex-farmer, called striking attention to the fact that

> Dairying is rightly regarded as a sound and mildly profitable part of our agricultural scheme. Still, within the last fifteen years, multitudes of fairly good dairymen have been forced to abandon dairying as unprofitable. In the face of this fact, seemingly gullible souls have bought herds and have made them pay for themselves besides making a living for their owners. Two and one half years ago a young man of my acquaintance was employed as a milker by two brothers. After five years of dairying the brothers took account of their assets, found that they were standing still financially and decided to throw up the sponge. They offered the herd of forty cows for sale for $5,000, and the farm for rent at $150 a month, $1,500 cash and the balance by the month, over a period of three years. My young friend had $1,700. A deal was made, and the erstwhile employee now has his herd paid for and the boarders replaced by profitable cows, besides having paid for a $700 milking machine and a good deal of miscellaneous equipment.

The same tale of inefficiency and the remarkable productive results which fol-

low scientific methods may be told elsewhere. Mr. Leber continues:

> Ten years ago, a poultry raiser called his foreman into his office and offered him a quit claim deed and bill of sale to land, buildings and the 4,000 hens on the place if he would assume all liabilities. To-day that foreman has a 7,000 bird flock, doesn't pay one cent of interest and discounts his current bills.

Yet as an indication of the phenomenal slowness with which the most obvious scientific methods force themselves upon the attention of farmers, consider this from *Wallace's Farmer* for October, 1928. It was stated therein that Iowa, with a three hundred million dollar swine business aggregating 40 per cent. of the total cash income of the Iowa farmer, actually had no swine association to coordinate production with consumption and to see that swine were reared scientifically and in proper number. An industry like General Motors or the General Electric would have begun to spend a million annually on a project so important years ago.

Again we find *Farm and Ranch* for August 10, 1929, uttering this plaint because farmers will not heed government bulletins:

> The government can give producers valuable information, but it can not make them take advantage of it. Let us call attention to the report on hogs. One was recently issued that fewer sows had been bred in this country than for several years; that cold-storage pork supplies were down; that the pig crop was small, and therefore there was reason to believe that the low point in the cycle of prices had been reached, and for another year prices would be apt to advance. How many farmers will take advantage of this state of affairs and make some money on hogs? This is what a lot of them will do: they will wait until prices start going up. They will hesitate some more and keep on hesitating until prices have about reached the high point. Suddenly they will decide that there is money in hogs and start raising a few. It will take them six months to get a litter ready for the market if they follow the approved rules of feeding and management, and longer if they don't. Thousands of farmers will do this and all will get on the market at once and break it. Prices start down because of the sudden increase in supply. Then those farmers will sell all they have, including their brood sows, and swear there is no money in hogs and never has been. They will go back into the business again about the same way and go broke again.

Returning to wheat—forty years ago the average annual production per acre in the United States was twelve bushels; now it is sixteen bushels. The figures for a few other countries where intensive agriculture has been developed scientifically are: United Kingdom, 32.4; Germany, 31.7; France, 19.1, and the Shantung Province in China, 42 bushels! (Damned clever these Chinese.) Nevertheless, conditions in this country are improving and we may catch up to the high Chinese standard of production after all. What we shall do when we get there is another matter deferred for consideration later herein.

In 1925 ten farm workers could do the work which required twelve in 1920 and fourteen in 1910. In colonial times, according to L. E. Call, of the Kansas Agricultural Experiment Station, 95 per cent. of all American producers were farmers, yet they scarcely clothed or fed their families. At that time our rural population was 96 per cent. of the whole; in 1880 it had dropped to 71 per cent.; in 1890 to 65 per cent.; in 1900 to 60 per cent.; in 1910 to 50 per cent.; in 1920 to 48 per cent., and on January 1, 1927, the Department of Agriculture estimated that but 24 per cent. of our people actually lived on farms. What did this disastrous trek to the city mean? In view of the back-to-the-farm fanatics our situation must have been desperate.

Not at all. Why? Because between 1917 and 1927 agricultural production increased 50 per cent. more than our population increased, and this was done on a stationary or perhaps a decreased acreage under cultivation. A human being as such develops but one sixth to

one tenth horse-power and requires sustenance of the highest grade besides. The agricultural use of horses increased the power in the control of man eight to ten times. But in 1918 Kansas alone had 5,400 tractors and in 1928 it had 50,000 in operation on its farms. Seventy-five years ago human and horse labor enabled a farmer to care for twelve acres of crop land; with modern farm equipment he can care for thirty-four acres, a 300 per cent. increase, and in some places, with the very best labor-saving devices, 300 acres may be cared for by a single man! Thus one man can do as much as twenty-five average farmers of seventy-five years ago, and we begin to ask—why shouldn't there be a migration to the cities and towns and is it so disastrous anyway?

Professor H. B. Walker estimates that if the 1926 Kansas wheat crop had had to be handled as wheat was handled one hundred years ago, it would have required the labor of 775,000 men for twenty days—or the entire male population between fifteen and sixty years of age and all females from twenty to thirty-seven. Three men could, with a little hard liquor, cut, bind and shock an acre of wheat a day a century ago. To-day three men could cut and thresh forty-five acres of wheat in a day and deliver the product to a market two miles away—and that without a shot of anything stronger than sweet cider.

That brings us abruptly to the chain farm idea, which is an increased production method now positively epidemic. It involves cooperative production and marketing under centralized direction, and banks and insurance companies now begin to look kindly upon holding large tracts of farm lands—say thirty-two farms in a tract of 7,500 acres in central Illinois—with each farm operated by a tenant and all under the efficient direction of a general superintendent.

Such a corporation in northwestern Iowa was owned by a group of Davenport business men and operated fourteen farms comprising 3,000 acres. The business was supervised by a full-time general manager. Each farm was handled as a separate unit and a net return of 9.5 per cent. on the investment was secured, a return which makes the individual farmer look a poor second indeed. In the *Illinois Farmer* for January 1, 1929, we read of

> Joseph J. Johnson who for four years has managed thirty-two central Illinois farms comprising 7,500 acres. Each farm pays $1 an acre per year for centralized business management. A bank owns the land and tenants operate the farms. Five-year leases prevail and a five-year permanent agricultural program is laid out. Tenant operators receive half of everything, land owner the other half. In five years, one 320-acre farm shows a net return of $19,620 or 6.13 per cent. on the investment. Mr. Johnson says it costs the average farm $26 to produce forty bushels of corn per acre with average sales price of $28, while the farm above mentioned spent $29 an acre to produce 70 bushels worth $49.

This tells the story of improved scientific efficiency. What of sentimental values? Dr. C. L. Holmes, of the state college at Ames, was reported in *Wallace's Farmer* for January 11, 1929, as saying that "men who work under supervision of this sort in the corn belt are likely to be of greater intelligence than most farmers." When asked what effect corporation farming might have on community life he replied,

> It need not be a poorer community life. On the contrary, it will probably be a richer one. While on the whole it will probably mean a smaller rural population in proportion to the land and capital involved, yet it should be a more intelligent and a more cooperative population, one constituting a better background for the development of worth-while community enterprises and community life.

Here we get a hint of the necessity for an agricultural deflation program in so far as the farm population is concerned numerically. We shall consider that

hint more extensively a little later. Two other instances of efficient farm production intrigue. One is from *Farm and Ranch* for January 26, 1929, and is as follows:

> County Agent A. B. Jolley has made a very interesting report relative to the progress being made by the farmers in Dallas County, Texas. Of importance is the fact that the farmers of this county are rapidly learning the value of community standardization of cotton. In the Rowlett community 5,000 acres were planted to a single variety. Six other communities are interested in community selection, and after making tests, it has been decided to make selections for 1929. Mr. Jolley also reports that backland farmers have found it very profitable to grow alfalfa, some of the growers averaging more than six tons per acre over a three-year period. Last year 1,323 bushels of pure-line Denton wheat seed was produced and sold to other farmers at an average profit of $1.50 per bushel over the regular market. This means that a number of other farmers will be growing pure-line Denton wheat in 1929. Many farmers also found it profitable to grow Nortex oats, increasing their yields and the quality of the grain. These oats sold at a profit of fifty cents per bushel over the prevailing market. One Dallas County farmer has developed a Yellow Dent corn that has averaged over sixty bushels per acre in bottom land. . . . Attention is also called to the fact that eighteen registered dairy bulls with high production back of them have been placed among farmers, and that 300 farms in the county have been terraced during the past six years.

The beneficent effect of community enterprise is very self-evident here.

In the southeast corner of Kansas 300,000 people in nine counties have gone unitedly after farm relief on the theory that "the Lord helps those who help themselves" and, perhaps, that the lazy farmer inclined to wait upon Congressional generosity does not deserve assistance anyway. They have created Southeast Kansas, Inc., backed it with money, intelligent management and community enterprise and put it to work to solve their problems. They have made a successful man of affairs chairman and have within their area twenty good towns, forty-eight newspapers, three hundred industrial plants, $60,000,000 in bank deposits, 500 miles of paved city streets and 38,000 home-owners, and they market annually some $50,000,000 of regular farm products, $3,750,000 of poultry and eggs, $3,000,000 of butter and $4,600,000 of milk and ice-cream. Their idea is to promote

> sound economy in agriculture, dairying, industry, and to work for better and more efficient markets. Through Southeast Kansas, Inc., we will jointly work for better and more efficient markets. Through Southeast Kansas, Inc., we will jointly work for better drainage, flood control which will serve us in wet as well as in dry seasons, good roads, better schools and for the place in the sun that our region is entitled to occupy. . . . We know that water runs down hill, that well-cultivated and properly fertilized land produces more than undrained, poor land, that competitive markets pay producers more than non-competitive markets do, that good roads and a balanced farm economy are profitable.

In short, these people in Kansas will not only become infinitely better agricultural producers, they will also enrich rural life at the very same time, and will almost inevitably decrease the necessity for a farm population of even the present size.

To-day the farm population of the United States is the smallest in twenty years, according to the Bureau of Agricultural Economics. It was 27,511,000 on January 1, 1929, as compared with a peak of 32,000,000 in 1909. The decrease would have been much greater had it not been in part offset by an excess of births over deaths. Some 1,960,000 persons left farms during the year, although 1,362,000 moved from cities to farms. The movement from the farms slowed up somewhat as compared with immediately preceding years, but the movement from cities to farms was somewhat smaller. Now, is this condition disastrous?

For long years we have constantly been regaled with a back-to-the-farm gospel as our only salvation. This gospel has been consistently dinned into our ears, in spite of the fact that the matter presented above plainly demonstrates the same trend of events in agriculture as in industry—increased production per unit of labor. In industry this situation has already produced a group of workers who are partially or totally unemployed due to the increased efficiency of machine production; the situation there would have been critical had not the automobile, the radio and other new industries come along opportunely to absorb part of the slack.

But we have to-day only about 800,000 efficient farmers. We are doing our best to make the remaining 5,700,000 farmers as efficient as this minority. If we actually accomplish this laudable aim what would happen? Let us again return to wheat to keep the subject as simple as possible. Our annual American production is about 800,000,000 bushels. Remember the low average per acre yield —sixteen bushels as against thirty-two in England and forty-one in Denmark. We export some 200,000,000 bushels of wheat annually. If we assume that we increase our yield per acre of wheat only 50 per cent., which would not be extraordinary, what on earth would we do with the rest of the wheat? It seems Heywood Broun was right.

No great extension of demand is possible. The American citizen is unlikely to be able or willing to eat more wheat—in fact, the modern nutritional tendency is to eat less of everything. Branches of agriculture devoted to the production of human food can not expect much increase in home demand. The export trade in food towards Europe is already declining, and India and China, in spite of recurrent starvation periods, can not afford to buy American wheat at prices satisfactory to American farmers. What is true of wheat is more or less true of all other American agricultural crops. Already the enormous potentialities of scientific agriculture, if put into operation quite generally, could so outstrip consumption that we should be fairly inundated with food if we had 6,500,000 efficient farmers. Under such circumstances a million or less farmers would amply supply us.

In short, the facts force us to believe that agricultural deflation must occur. As farming becomes more efficient some twenty million people must be absorbed by city industry. While this would, if spread over a period of twenty years, be no greater job than the absorption of a million European immigrants annually, which we accomplished regularly before the quota policy was introduced, it would probably present a difficult problem simply because machine production gains annually in efficiency. Nevertheless, it does not look as if there is much hope for these people if they remain on the farm. We may be called upon to cook and eat a few of them, but we certainly can not have them uselessly cluttering up our farms when agriculture becomes as scientific as the Department of Agriculture could make it right now, given proper facilities for distributing the knowledge it has already accumulated.

In 1926 Sir Daniel Hall gave a presidential address on food and population to Section M (Agriculture) of the British Association for the Advancement of Science. He presented data to demonstrate that the average consumption of food and raw material by white peoples requires from 2 to 2.5 acres per head and that, since the white population of the world increases at the rate of five million per annum, there must be a commensurate increase of 12,500,000 acres per annum under cultivation, or else a proportionate increase in yields on the existing acreage, since there are no new

areas worth speaking of to be opened up. It is this intensive agriculture which our Department of Agriculture seeks to inculcate. Next, the concluding paragraph of a brief editorial entitled "The Future of Agriculture" in *Nature* (London) for July 20, 1929, is apposite.

> This [Sir Daniel Hall's view], of course, may still remain true as the expression of a general tendency for the greater part of the world which is bound to operate in the long run; but if the American position is really that which has just been described—namely, overproduction even though a great majority of the farmers are producing at a very low level—then it would seem that the general rule enunciated by Sir Daniel Hall appears to be subject to substantial local or temporary checks; although, on the other hand, it is quite possible that the American position has not been quite correctly diagnosed, and certainly some rather large assumptions have been made. One may yet conclude that the bounty of nature and science is far greater than we have ever envisaged in our wildest dreams, that the law of diminishing returns may be suspended almost indefinitely and that there is—and will be for some time—an economic limit to the extent to which the world, as a whole, can employ the mighty powers and resources of modern science in the realm of agriculture.

In other words, the farmers better begin to lie abed longer, as Heywood Broun advised, or they may soon be starving in droves. This would almost certainly clutter up the highways in such manner as seriously to interfere with the progress of automobile tourists and would, therefore, be most objectionable. The only thing left for the farmers to do is go to the city and work in factories. It is said that six pall-bearers were recently conveying the remains of a prominent industrialist down the church aisle when he suddenly came to life and exclaimed: "Put this infernal thing down immediately and get a truck; fire five of those men and let the other one push it." The story, perhaps apocryphal, at least adumbrates the situation the agriculturists will find confronting them in the city, but it would not be possible to speculate what might be done regarding that without making this article entirely too long.

A NEW PSYCHOLOGY AFTER THE MANNER OF EINSTEIN

By Dr. PAUL CHATHAM SQUIRES

CLINTON, NEW YORK

I

In an era marked by such intense interest concerning things psychological as is the present one, many aspects of psychology have found expression in the popular literature. Especially have the problems of sex and the occult found a dominant place in the public mind. But there is a most fascinating chapter in psychology, hitherto unrevealed to the layman, that affords a striking comparison of a new movement in psychology with the principle of relativity made current and popular by the great physicist Einstein.

The essence of that which has been stored in the abstruse treatises of the professional psychologist may readily be grasped by thousands of intelligent readers provided the story is stripped of its academic clothing. And it is the purpose of the following pages to portray in a simple manner the teachings of the youngest member of the psychological family, a new psychology that adopts the spirit of Einstein's approach to the realities of the universe. This new psychology goes by the significant name of the Gestalt psychology, which means in our language the configuration psychology, and is perhaps chiefly remarkable for its intimate connection with modern physics.

The Gestalt psychology, arising in Germany within the course of the past two decades, has been enthusiastically heralded by some as furnishing the one and only adequate key to the problems of mind, while by others it has been made the target of violent criticism. Whatever the final verdict of science in respect to the claims of this new school of psychology may be, configurationism has at any rate succeeded brilliantly in agitating and redirecting the currents of traditional thought. For just as Einstein gave an impetus to physics by expounding the relative nature of space and time, so the champions of the configuration psychology have been assiduously engaged in the attempt to demonstrate the relative character of our mental life, and have thereby imbued present-day psychology at large with renewed vigor.

Every one has a practical understanding of the word configuration. It means the outline, the shape, the contour of an object; thus, we may speak of the configuration of a human face or the configuration of a mountain. And when we are studying the configuration of something we are either ignoring or treating as unimportant for our present purposes the elements, the bricks as it were, which enter into the composition of the given structure.

The use of the term Gestalt or configuration, then, implies that our attention is focused upon the object-considered-as-a-whole, and not upon the object-considered-as-consisting-of-parts. Here you have unearthed the fundamental clue to the secret of the configuration psychology. For this new psychology interests itself primarily, if not exclusively, with the form, rather than with the so-called elements, of mental activity. The older psychology, however, was preoccupied with a highly abstract dissection of mind into its ultimate parts, and hence strongly resembled an atlas of anatomy. Toward this anatomical attitude the configuration psychology is utterly hostile.

The older psychology, with all its talk about "simple sensations" and "pure reflexes," was far removed from the realities of every-day life. Freud brought forward his sex psychology at the turn of the present century, and this, in its many variations, has served as a partial if not always perfectly acceptable antidote to the undue abstractness of the classical psychology.

The development of the mental test represents another one of a number of comparatively recent tendencies toward a more practical and realistic view of human nature. And the American behaviorists have made notable contributions to the cause of evolving a psychology that may more effectively enable us to direct the progress of the individual through his social world. The latest arrival on the scene, the configuration psychology, is endeavoring to carry out a program in which the ordinary meanings encountered in daily existence are made the vehicles of a set of scientific principles that find their parallel in Einstein's doctrine of physical relativity. This is most assuredly a novel undertaking.

II

Let us make the acquaintance of the new relativity psychology by means of a not unusual example taken from the colored moving pictures. Suppose a patch of green to appear somewhere on the cinema screen, and furthermore suppose that, perhaps on account of absentmindedness, you have as yet attached no definite meaning to this expanse of green. The green so far means neither green water as viewed in the distance nor the green of foliage; it is simply greenness to you and that is about all. Suddenly you come to realize that this patch of green represents, *means*, the blue sky, and instantly thereupon the green is transformed into a fairly natural appearing area of blue sky. Thereafter, no matter how hard you try to change the blue back into green, you will fail. Here we observe one of the operations of the law of psychological relativity. The traditional psychology taught that a color possesses a more or less absolute, unchanging character. Green, for instance, according to this older mode of thinking, should be green anywhere, regardless of the meaning which it bears. But the simple observation just described would seem to show conclusively that color quality is a matter relative to the meaning borne by the quality.

Again, when we try to estimate the amount of redness cast upon a snow field by the rising or setting sun, it has been experimentally determined that we consistently underestimate the amount of redness present. The mind makes allowance unconsciously for the fact that snow is white and the redness diffused over it by the sun is accidental only, is merely in temporary connection with it. The meaning of snow has a powerful effect in forcing the observer to perceive a less amount of reddish tinge than he would see provided this meaning were absent. You can demonstrate this fact to yourself sometime by first gazing at the snow in the ordinary manner and then by looking at a restricted extent of it through a paper or cardboard tube. When you look through the tube be sure to eradicate as completely as you can the meaning of snow, to which over a long course of experience you have come to attribute a highly stable whiteness. This is to say, get the color-meaning of snow to lapse from consciousness. If you are moderately successful in doing so, the limited area surveyed fixedly through the tube will come at last to mean nothing much in particular, and you will discover that a far larger amount of redness is present than is observed under the ordinary conditions. Thus this little experiment gets at the roots of a profound psychological truth; namely, that a quality, whether a

color quality or any other sort of quality, for that matter, depends for its precise character upon the context, upon all the relations, in which it stands. A quality as perceived by us is not absolute but relative.

This doctrine of psychological relativity finds application both to human and animal response. Through the study of animal behavior we frequently gain the advantage of being able to observe the working out of psychological principles in a more primitive, simple manner than is the case at the human level.

Construct in a goldfish tank two wooden compartments, each having an entrance large enough for your goldfish to pass through. Place these compartments side by side and slightly apart at one end of the tank and illuminate each independently by means of an electric light. The electric lights are hooked up with an instrument called a rheostat, which enables the experimenter to control the brightness of each light, raising or lowering the illumination at will. After having darkened the room in which the tank stands, illuminate one compartment with a rather low light intensity which we will designate for convenience intensity *A*, and the other compartment with a somewhat higher intensity *B*.

Now, release a hungry fish at the end of the tank opposite the lights, first having taken care to place some food in the more brightly illuminated compartment. The fish will swim toward the lights and, in the course of its explorations, will pass eventually into the brighter compartment, where it will find food. As soon as the fish has obtained the food repeat the experiment. But this time arrange it so that the brighter light is in the other compartment, in order that the fish may learn to react to this brighter light regardless of its position at right or left. Shift the relative position of the lights in a chance order over a series of trials lasting a number of days, and you will discover that at last the goldfish swims in a direct and speedy manner to the brighter light *B*, without making a single error.

According to the contentions of the older psychology, the goldfish would be said to have learned to respond selectively to the absolute, not the relative, brightness of light *B*. But does it really react in this way? Let us see.

After the training of the fish has been fully established, we now proceed to subject the animal to what is known as the "critical test." This test is conducted by leaving light *B* at its original brightness and raising the intensity of light *A* to an intensity which we will call *C*, the brightness of *C* being somewhat greater than that of *B*.

Bear in mind that the goldfish has been taught to pick out light *B*. But when the fish is presented with the two lights *B* and *C*, it responds without hesitation to the latter light, although the former light was the one which it had learned to choose. Evidently, what the animal was all along responding to was not the light *B* considered by itself, but light *B* as a member of the pair *A B*, of which it was the brighter member. The fish is responding to the brighter of two lights. It is reacting to a light as a component of a total situation. The animal behaves in a relative, not in an absolute, manner. Here we witness the conflict between the older and the newer interpretations in the field of psychology.

The moving picture illusion furnishes us with another example through which may be understood the point of view of the Gestalt psychology. This illusion has attracted much attention as a scientific problem, but it is as yet by no means fully explained. The apparent motion perceived by us is produced by a rapid succession of stationary photographs, but just how this effect is brought about is the question. The more common ex-

planation amounts to about this: that exactly as one can whirl a firebrand around in the darkness so as to obtain the appearance of an unbroken circle of fire, the so-called positive after-image of the flame seen at different positions of the whirl fusing to give the form of the circle, so in the moving picture illusion the effect is produced by a union or fusion of the stationary positive after-images, each one of which means, perhaps, a race-horse in action.

The classical psychology would carry its dissection of the perception of illusory motion to the point where the perception is described as the *outcome* of an addition of stationary visual images. But here the configurationists raise an objection. They have experimented on the illusion under many different conditions and maintain as the result of their investigations that the perception of motion is to be interpreted as one indivisible whole which can not be reduced to such parts as images without incurring the annihilation of the illusion. An anatomical attitude assumed by the observer toward the illusion destroys it.

As an especially forceful line of evidence, the configurationists, and some others for that matter, claim that they have observed the illusion of motion without anything moving. This is one of the paradoxes of science. How can motion be seen apart from some object carrying the motion? Absurd as the notion of "pure motion" may seem, however, there does appear to be sound testimony as to its at least occasional occurrence. If movement can be apprehended as separate from a thing bearing the movement, is not this fact overwhelmingly in favor of the unitary, totalized nature of the movement process and opposed to the idea that the perception of motion is nothing but a summation of after-images and sensations of eye-muscle strain? Whatever may be the ultimate decision concerning the experience of "pure motion," this supposed fact of vision has led to much emphasis upon wholes rather than upon parts, upon unities rather than upon simple elements. And the Gestalt psychology is untiring in its description and explanation of totalities in the field of experience and behavior.

The intimate relation between space and time is being brought home to us constantly. Spatial values are shrinking from year to year. A few hours now suffice for the traveler to span the continent. A giant airship flies around the world in a few days. As speed increases, distance decreases. So we come to say that distance depends on, is a function of, time. As in the practical activities of our daily lives we recognize this fundamental fact of relativity, so the psychological laboratory gives detailed information about it.

Take, for instance, such a simple and yet such an enlightening experiment as the following one. Have some person close his eyes, and then, using the blunt point of a pencil, touch him now at one position and then at another on the back of the hand. If you take care to place the two successive touches always the same distance apart as measured in terms of inches, but vary the rate of the touches, you will find that the person upon whom you are experimenting will report that the greater the rate of stimulation the shorter the apparent distance between the touches. And just as in the case of vision it is possible to produce the illusion of motion, so in the field of touch, if the two stimulations are speeded up, there finally comes a stage where the experience of a mere succession of touches is replaced by the experience of one point in continuous motion over the surface of the skin. So it has also been asserted that there is a most curious illusion of movement in hearing, where two sharp sounds are presented first to one ear and then to the

other with an extremely brief time interval between the sounds. Throughout all these interesting experiences we have the opportunity of observing the complicated interlocking of space and time.

Not only is there a most intricate relation between space and time, but also between these two and the intensity of whatever object may be involved. We say that one light or sound is more intense than another; and the magnitude of an object is a special form of intensity. Quite recently it was discovered by the configurationists that in a simple version of the moving picture illusion the direction of movement of a line, for instance, could be reversed by merely altering the intensity relations between the successively presented pictures. The new psychology has worked out three fundamental laws showing the mathematical relations between space, time and intensity values requisite for obtaining the movement illusion.

This is a truly scientific approach to the problem, and illustrates aptly the method of the configuration school. For this method is based upon the assumption that the knowledge of certain physical properties possessed by the material agents in the world outside of the organism will enable us to predict the nature of the resulting experience and behavior.

But these purely external conditions are not of themselves always and ever sufficient to bring about a desired effect. The attitude of the observer is a matter of no small importance. Unfortunately, psychologists have found the problem of attitude a most tangled one, but progress toward the solution is gradually being made. However, the occasional failure of the three laws just mentioned does not imply the incorrectness of these laws, for there are laws of a "higher order" residing within the one who is doing the reacting.

The explanations of the configuration psychology are couched both in physiological and in physical terms. Take, for instance, the explanation of the illusion of motion advanced by the configurationists. The older and more prevalent account given of the physiological mechanics involved in this illusion has considered absolutely essential the operation of at least two brain levels. We may compare brain levels to the stories of a building, although this analogy has latent in it some very absurd features. The older theory would say that the perception of movement is mediated more particularly by the higher level. The materials entering the lower story from the eyes are in a raw, chaotic state, and it is necessary for the mechanics of the upper story to organize and unify the materials deposited in the lower story before the perception of motion results.

The configuration theory, on the other hand, has speculated on the possibility of the illusion of motion being mediated at the lower brain level, this level doing the entire work. The theory in question invokes a short-circuiting process at the lower brain level, analogous to the short circuit that once in a while occurs in a network of electric wires. The nerves in the brain correspond to the electric wires. This explanation has been set forth by the Gestalt psychologists in terms of the physics of nerve transmission. In fact, as will be pointed out in more detail below, the architecture of the configuration theory emerged out of the abode of modern physics.

III

Primitive man saw in human purpose the expression of the will of good and evil spirits. In nature, the lightning and the whirlwind voiced the wrath of a god. The coming of modern science has enabled us to understand the events of physical nature in terms of natural causes, but the struggle to interpret human action without reference to su-

pernatural agencies has been long drawn out and severe.

Consider the manner in which the configurationist would solve the mysteries of purpose. Cover a section of fine-meshed wire netting with a soap-bubble film. Cast upon this film a loop of thread. In all probability the loop will assume a highly irregular form. Prick the film somewhere within the loop and see what happens. At the moment of pricking, the loop jumps into a shape, a configuration, that shows a strongly circular tendency.

Observing all this, you would not think of saying that the alteration in the form of the loop was brought about by supernatural means. You would seek to explain the fact by reference to surface tensions. Purely physical laws are here active. No genie has directed the shift in form. The little loop of thread has been forced into the shape demanded by the physical law of the expenditure of least possible energy. It has passed into a new state of equilibrium that is in harmony with the change in surrounding conditions, and the tendency has been in the direction of simplification of form, from the irregular to the symmetrical.

The law of least energy, so say the Gestalt psychologists, applies not narrowly to the world of matter but also to the world of mind. Pause for the moment and consider how this law is operative in the fields of perception and memory.

Imagine twelve small white disks against a black background, arranged in such a way that the disks, if joined together by straight lines, would form a regular twelve-sided figure. Now alter this pattern so that any one of the disks is somewhat farther from the center of the figure than the other eleven disks. This alteration has of course destroyed the symmetry of the figure; the pattern now appears to you to be out of balance. If this unbalanced figure is presented for a small fraction of a second a strange thing will be seen to happen. The displaced disk shoots inward toward the position it would occupy were the figure to become a regular, simple, balanced one. Of course, no motion has occurred in the physical sense of that word, but nevertheless the illusion of motion is experienced.

This fact of perception holds many possibilities for a more adequate insight into the nature of mind. Here is to be witnessed the ultimate similarity between the psychological and the physical aspects of the universe. Just as the loop of thread had to pass from a more complex to a simpler form, according to the law of least energy, so did our perception of the unsymmetrical twelve-sided figure undergo a change toward symmetry and simplicity, toward the best possible equilibrium.

Again, show some one a number of irregular and more or less complicated geometric designs. Ask him to study these designs for a few seconds each. Next day have the person draw the figures from memory. Repeat this performance for a few days and compare the results obtained from day to day. The Gestalt psychologists have claimed that these drawings reveal the law of simplification. For, say they, the successive drawings assume more and more simple form, instead of becoming more complex.

These two illustrations taken from perception and memory are samples that have been used to indicate that human behavior and physical events are different expressions of purely natural law. Human conduct, however, on account of its immense complexity, is at first view incomprehensible in terms of natural law. Hence, mankind in general has always dragged in the notion of some undefined, mystic, supernatural Purpose to explain this conduct. The configuration psychology has been a leader in the

scientific movement to close the ancient gap between mind and matter. It has interpreted purposeful activity, the seeking after goals, as a natural, not a supernatural, event. To be sure, the configurationists are not the first to have suggested this type of solution. But they have related human and animal purpose more effectively to the facts and theories of modern physics than have their predecessors.

IV

The standard-bearers of the Gestalt movement are carrying into execution a frontal attack on the great enigmas of mind. They are delving into the problems of sense perception, memory, learning and intelligence. Of late years they have been probing into the mysteries of insanity and the sources and nature of our appreciation of the beautiful. The Gestalt theme with variations is the supreme importance of the total situation and the organism-considered-as-a-whole. Whatever parts may be recognized to exist are not prior to, but grow out of, the original, primal whole. Furthermore, the foundation laws of psychology and physics are identical.

Configurationism and Einstein's doctrine of physical relativity seem to be developing in parallel directions, notwithstanding the fact that the subject-matter of each appears on the surface to be so completely different from that of the other. Einstein protested against the conventional world scheme of Sir Isaac Newton. Einstein begins the story of the physical universe not with such unrealities as absolute space and time but with the account of two bodies in motion relative to each other; he dispenses summarily with a fixed framework of space and time.

For Newton, space and time values are independent of the position of the human observer and are presumed to be identical for every segment of the cosmos. For Einstein, these values depend directly upon the position of the observer. All physical evaluations are purely relative to the particular total situation within which they are calculated. Also, the combination of velocities is not a merely additive matter, but is something more than a straightforward summation. Here we see pronounced the apparently revolutionary proposition that even at the purely physical level the whole is not equal to the sum of the parts.

For the traditional psychology, particular experiences and bits of behavior possess a more or less absolute character. For the Gestalt psychologist, any aspect of mentality has meaning only in its relation to the larger context, the whole, in which it exists. Configurationism begins its narrative with an account of the ordinary meanings of common sense, the wholes of experience, which may be encountered in every-day life. It does not begin with a description of fictitious parts called pure sensations and reflexes.

To the classical psychology, human perception, for instance, is viewed as a mosaic, as a bundle of originally meaningless psychic atoms called simple sensations. For the Gestalt psychology, every perception, whether of a person's face or of anything else, exists in its own right, is itself. The perception is something over and above the sum of its supposed parts.

But the configuration doctrine, in spite of its apparent novelty, owes a big debt to history. What scientific movement does not? Einstein, for that matter, had his predecessors more than two thousand years ago. The configurationists are not the only psychologists to have recognized the idea of psychic relativity, although they are the first to have elaborated the idea into a workable system. The origin of the notion lies in the dim past. Perhaps we might trace its nearer origins to

the founder of experimental psychology, Wilhelm Wundt, of the University of Leipzig. But that is another story. Suffice it to say that the concept of relativity in the domain of mind has been evolving slowly but surely. The configurationists, however, merit the distinction of being the first to develop this concept scientifically.

Mind is the outstanding riddle of the universe. Because of the well-nigh unbelievably great complexity of its subject-matter, psychology has lagged in the rear of the conquering advance of the physical sciences.

But, notwithstanding the manifold difficulties confronting the student of mind, it seems certain that the doctrine of psychological relativity as enunciated by the Gestalt school will lead eventually to a thorough readjustment and advancement of psychology at large. Already can there be detected the beneficial influence of this mode of thinking upon current American and European psychology. Whether or not its chief value will finally be found to consist in its rôle as a method rather than as a point of view is a question that need not detain us here.

Whatever the verdict of posterity may be, the Gestalt psychology has attempted the remarkable feat of giving due tribute both to the common-sense meanings that have always been the property of the ordinary man and to the most inclusive world scheme of all time, the Einstein doctrine of physical relativity.

SOME DEMOGRAPHIC CHARACTERISTICS OF AMERICAN EDUCATIONAL CENTERS

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IN the SCIENTIFIC MONTHLY for March, 1920, the writer described a method of measuring civilization by means of a graded classification of occupations, based on city directories, alumni catalogues, etc. Since that time there have been published the reports of the 1920 census of the United States, which analyze the returns more minutely than previous censuses and afford some additional measures of civilization, which though indirect are simple to apply and can be had for every county and city in the country.

Civilization, or aristocracy, may be based on either wealth or culture. These things of course are not synonymous, and one can easily find individuals who have a good share of one and not much of the other, but in a whole city, country or state they generally go together pretty well. The U. S. Census Bureau has published statistics of per capita wealth, incomes, etc., at various times, but they are subject to differences of interpretation, and do not mean much for areas smaller than states, for persons living in one city or county may own considerable property in another.

An indirect index of wealth is afforded by the age distribution of the population, which may be expressed in average or median age, proportion of persons under ten or over twenty-one (or any other age), or size of families. For most adults are breadwinners and most children are not, and consequently a community with a large proportion of adults is pretty sure to be more prosperous than the other extreme; and the increase in per capita wealth in all civilized countries in the last hundred years or so may be ascribed largely if not mostly to the well-known decrease in the size of families. In the United States at the present time the adult percentages range from about 40 in some of the mountain counties of Kentucky and Virginia to 75 in Palm Beach, Florida; and they are tending to increase everywhere as the expectation of life is prolonged by medical science.

From 1830 to 1860 one can get from census reports the number of persons under ten or twenty, and the approximate number of adults, in every county. For the censuses of 1870 to 1910 inclusive most such data are given for states but not for counties, though in 1910 the number of persons under ten in each county and city can be ascertained from the illiteracy figures. For 1920 the age statistics for counties are more satisfactory.

The greater the proportion of adults of course the fewer the children, and therefore the smaller the families—for few families have more than two or three adults, while the number of children may range from none to a dozen or more. Not only the total number of persons per family is of interest, but also the number of men, women and children separately. (For counties and cities such data are available in 1920 more completely than ever before, though families of different races were not separated then as well as they were in 1910.) The number of men and women per family is an index of the average age of marriage. For if it was customary for every one to marry and start a new family at the age of twenty-one there would be just about one man and one woman per family, the oc-

casional loss of husband or wife being just about balanced by cases of old people living with their married children. But if a young man or woman remains single for awhile after passing twenty-one, then he (or she) is an extra adult in some family, either that of his parents or in a boarding-house somewhere else.

It is well known that people marry a little later in the North than in the South, and in the city than in the country, and whites later than Negroes, and these tendencies are reflected unmistakably in the number of men and women per family in different communities or races. But in the whole United States the number of men and women per family, and therefore presumably the average age of marriage, has changed very little since 1850; and in single states and smaller areas the averages are probably also reasonably constant from one decade to another, unless the character of the population is changed by migration.

The most direct measure of civilization afforded by our census statistics is the illiteracy count, which has been given for various population groups in every census since 1840, and for 1920 is available for adult males and females (and some other age groups) in every city and county. It is a rather crude measure, for it lumps together college graduates and people who can barely read and write, but when used in connection with other measures of either wealth or culture it shows a fair degree of correlation.[1]

Another fairly good indirect index of culture, which has been very little used, is the sex ratio. For males are generally greatly in excess in such primitive communities as mining and lumber camps and cattle ranches, and moderately so in city slums, while females generally predominate in college towns, summer resorts, etc.[2]

Useful indexes obtainable from other sources than the census are the detailed circulation figures for various magazines that appeal to intelligent people, and the ratio of noted persons (typified by names in "Who's Who in America") to total population, adult population or families.

The use of such statistics to measure civilization will now be illustrated by a study of twenty-five educational centers, in seventeen states, scattered from Massachusetts to California. The cities selected are as far as possible those in which a college or university (or sometimes more than one such institution) is the dominant factor in the life of the community. Some college towns also contain factories, employing large numbers of people who need very little education in their business, and these (with two or three exceptions which will be mentioned) are excluded from the study. Those with less than 80 per cent of their population white are also excluded, to minimize possible complications due to racial differences. It is also necessary to confine the study to municipalities with at least 2,500 inhabitants, for recent censuses give no information about the smaller places except the total number of inhabitants.

For these reasons all college towns south of West Virginia and east of Arkansas are excluded, for they are all either too small or have too many factories or Negroes to be typical. Some which seem to measure up to the re-

[1] Some educators or uplifters profess to regard illiteracy as a symptom not of lack of culture but of lack of opportunity; and they hope to "eradicate" it entirely from the United States before the next census, and thus do away with one of our yardsticks of civilization. For all such measures of quality of population seem to be obnoxious to people who make "democracy" a fetish. But there would not be much use trying to have civilization if we could not measure it occasionally and see what progress we are making.

[2] This measure, however, gives contradictory results when applied to different races, for if the census figures are correct the proportion of females is nearly everywhere larger among Negroes (especially mulattoes) than among whites.

quirements in everything except size are Chapel Hill, N. C., and Auburn, Ala. In the ratio of "Who's Who" people to population Chapel Hill seems to be ahead of all other municipalities in the United States, with the possible exception of Princeton, N. J.; and if its population is over 2,500 in 1930, as seems probable, we can then find out some very interesting things about the place.

Some of the colleges in the cities and towns under consideration are for men only, some for women, and some coeducational, but that seems to make little difference in the sex ratios of the communities, for students are supposed to be counted in the census at their homes, rather than where they go to college. (Another plan, which the writer used in the Florida state census of 1925, and which has some obvious advantages, is to make a special enumeration of educational, charitable, penal and military institutions, and tabulate them separately from the counties or cities in which they are located.)

The statistics in the following table are all for January 1, 1920, or the nearest possible date. Of course there have been some changes since, especially in the number of inhabitants, on account of the rapid growth of all our colleges since the World War, but there is no reason to expect that the next census will show any marked changes in the various ratios. The communities represented are first the whole United States and its urban and rural population, for standards of comparison. Then three cities which are too large to be typical educational centers, but are included for special reasons; Washington because it has a very small industrial population, and ranks high in many measures of culture, and New Haven and Cambridge because they are the seats of two of our oldest and largest universities. Washington, unlike all the other places listed, has less than 80 per cent. of its population white, but if statistics had been computed for whites only (as could have easily been done) the results would not have been very different from those here presented.

Finally there are twenty-three cities and towns regarded as typical educational centers, arranged in order of size, and at the bottom the unweighted averages of all the ratios for these twenty-three places. The number of places studied had to be limited in order to economize time and space, but if a larger number or an entirely different list had been used, and true instead of unweighted averages calculated, it might not have made much difference.

The kinds of statistics used are the percentage of whites, males and adults, the number of persons per family (also separating men, women and children), the ratio of children (under twenty-one) to women (over twenty-one),[3] adult illiteracy for both sexes, combined and separately, the percentage of families represented in the 1920 edition of "Who's Who in America" (assuming that there is not more than one such person in a family), and the percentage of "wage-earners" (in factories, in 1919) in the total population. Statistics of magazine circulation and a few other things could have been given if space had permitted, but they would probably show no marked departure from the tendencies here indicated.

About two thirds of the "wage-earners" in Washington are not in regular factories, but in governmental establishments such as the Navy Yard, Bureau of Engraving and Printing and Government Printing Office; but their social significance is essentially the same as if they were in factories operated for profit. The census gives no data on factories and wage-earners for cities with fewer than 10,000 inhabitants, which

[3] For the significance of this ratio see *Jour. Heredity*, 18: 217–223. 1927; 19: 172. 1928.

accounts for the blanks in the lower part of the last column. Neither does it separate white and colored wage-earners; but that makes no difference in the present study.

On examining the table it will be seen that every city in the list, without exception, has more women than men, though this can not be said of most of the states in which they are located.[4] The only ones that have less than 60 per cent. of adults are located on the edge of the South (which has a higher birth-rate than the rest of the country, and therefore a larger proportion of children).

Most of the cities have less than four persons (including less than 1.5 children) per family; and the exceptions, if investigated, would probably be found to be due either to other businesses than education or to a considerable number of unmarried teachers living in boarding-houses (indicated by more men and women per family than the average). From what has been said above about the relation of the number of adults per family to the average age of marriage, it would seem that in comparison with all American cities, the men in college towns tend to marry earlier, this doubtless on account of the opportunities afforded by the surplus of women; while the matrimonial opportunities of women in such communities are correspondingly less. The number of old maids in college towns has long been proverbial; and it would seem from the table that spinsters or widows, or both, must be especially numerous in Washington, Evanston and Wellesley.

The ratio of children to women in college towns averages around 1, as compared with 1.20 for all American cities in 1920, and 1.92 in the rural districts. This would seem to indicate an approximate equality between births and deaths in such places (which may characterize the whole United States about the middle of the present century, if the birth-rate continues to decline as it has been doing in recent decades).

In the whole United States, and especially among foreigners and Negroes, there is more illiteracy among women than among men; but most of the college towns show the opposite tendency, indicating a superior class of women there. The adult illiteracy is greater than some might expect, being seldom less than 1 per cent. in 1920, if the communities selected are typical. But where it is over 3 or 4 per cent. it may be due mostly to foreigners or Negroes who have no connection with educational institutions. Incidentally, the presence of so much illiteracy in educational centers as late as 1920 suggests the futility of the hopes of those who would like to "eradicate" it from the entire nation by 1930.[5]

The "Who's Who" percentages run below 1 in only a few cases. College towns rank far above other communities in this respect, though it might be charged that "Who's Who" includes a disproportionate number of educators and librarians who seldom if ever write for publication and are therefore known only to a small circle of students and friends. The statistics of wage-earners probably need little comment, except to call attention to the footnotes pertaining to the last column.

It would be beyond the scope of the present paper to give similar statistics for communities verging toward the opposite extreme of American civilization, but any reader who is sufficiently inter-

[4] In all the cities with over 10,000 inhabitants listed in the table—and probably also in the smaller ones, though the census gives no such details for them—females are in the majority at all ages above ten, though in the aggregate urban population of the United States there is an excess of males between the ages of thirty and seventy, as well as below ten.

[5] Another difficulty in the way of the eradication project is that about one person in a thousand in almost every community is insane or idiotic, so that 0.1 per cent. may be taken as an irreducible minimum for illiteracy.

SELECTED STATISTICS OF AMERICAN EDUCATIONAL CENTERS, ETC., 1920

	Total population	Percentage of			Persons per family				Children per woman	Percentages of				
										Adults illit.				
		Whites	Males	Adults	Total	Men	Women	Children		Total	Men	Women	Families in "Who's Who"	Wage-earners
Whole United States		89.7	51.0	57.6	4.34	1.29	1.21	1.84	1.52	7.12	6.98	7.26	0.10	8.6
Urban population		93.2	50.1	62.4	4.24	1.34	1.32	1.58	1.20	5.50	5.14	5.87	†	14.3*
Rural population		86.0	51.9	52.4	4.45	1.23	1.10	2.12	1.92	9.15	9.19	9.10	†	4.4‡
Washington, D. C.	437,571	74.6	46.5	69.8	4.55	1.45	1.72	1.38	0.80	3.34	2.99	3.63	1.62	7.0
New Haven, Conn.	162,537	97.1	49.3	60.5	4.48	1.33	1.37	1.78	1.29	8.10	7.17	8.99	0.58	19.0
Cambridge, Mass.	109,694	95.0	47.8	63.3	4.33	1.28	1.46	1.59	1.09	3.88	3.73	4.01	1.18	20.5
Berkeley, Calif.	56,036	96.7	46.9	67.6	3.70	1.14	1.36	1.19	0.88	1.23	1.41	1.12	1.09	4.1
Madison, Wis.	38,378	99.2	47.8	65.5	4.08	1.26	1.41	1.42	1.01	3.28	3.72	2.88	1.73	8.3
Evanston, Ill.	37,234	93.2	46.0	65.0	4.40	1.28	1.58	1.53	0.97	2.46	2.69	2.28	1.77	3.8
Poughkeepsie, N. Y.	35,000	97.5	47.7	64.6	4.02	1.22	1.38	1.42	1.03	4.56	4.58	4.52	0.39	16.9
Ann Arbor, Mich.	19,516	96.9	47.0	68.0	3.67	1.15	1.34	1.17	0.88	1.82	2.25	1.44	1.92	8.2
Ithaca, N. Y.	17,004	97.3	46.6	68.6	3.60	1.14	1.33	1.13	0.85	1.70	2.05	1.40	2.66	9.9
Lawrence, Kans.	12,456	82.3	46.5	64.0	3.58	1.05	1.26	1.28	1.02	1.83	1.70	1.92	1.30	4.0
Morgantown, W. Va.	12,127	97.7	49.5	58.6	4.12	1.19	1.22	1.71	1.40	1.40	1.51	1.28	0.78	10.7
Bloomington, Ind.	11,595	95.8	49.1	59.3	3.80	1.09	1.16	1.55	1.33	3.46	3.76	3.19	1.08	12.2
Iowa City, Iowa	11,267	99.2	45.5	67.7	3.69	1.11	1.39	1.19	0.86	1.01	0.65	1.30	1.77	2.9
Boulder, Colo.	11,006	98.8	45.8	64.5	3.70	1.05	1.33	1.32	0.98	0.34	0.38	0.30	0.70	1.5
Eugene, Oregon	10,593	99.8	47.2	65.0	3.54	1.08	1.23	1.23	1.01	0.52	0.40	0.63	0.33	5.0
Columbia, Mo.	10,392	81.5	46.9	63.9	3.64	1.07	1.26	1.32	1.04	5.62	5.71	5.55	1.89	2.7
Urbana, Ill.	10,224	96.7	47.1	63.8	3.88	1.14	1.35	1.40	1.05	1.32	1.50	1.16	3.68	5.0
Manhattan, Kans.	7,989	96.3	47.8	63.3	3.78	1.14	1.26	1.38	1.10	0.77	0.83	0.72	0.38	†
Ames, Iowa	6,270	99.3	48.5	65.0	3.66	1.14	1.24	1.28	1.03	0.49	0.56	0.42	1.28	†
Wellesley, Mass.	6,224	99.4	44.5	65.5	4.46	1.21	1.71	1.54	0.90	2.94	3.90	2.26	2.08	†
Princeton, N. J.	5,917	82.5	48.2	67.7	3.84	1.25	1.36	1.24	0.92	3.91	4.12	3.74	8.60	†
Palo Alto, Calif.	5,900	95.7	46.4	68.0	3.55	1.07	1.33	1.14	0.86	0.27	0.39	0.18	5.06	†
Amherst, Mass.	5,550	96.8	47.2	64.4	4.05	1.18	1.43	1.45	1.02	4.40	4.15	4.60	3.14	†
Fayetteville, Ark.	5,362	94.2	47.2	58.4	3.95	1.08	1.23	1.64	1.34	3.36	3.82	2.94	1.33	†
Norman, Okla.	5,004	99.7	47.5	58.5	4.18	1.16	1.29	1.73	1.35	0.92	1.01	0.85	0.92	†
Williamstown, Mass.	3,707	97.4	48.6	64.4	3.97	1.23	1.32	1.42	1.07	2.52	2.52	2.52	3.10	†
Average of 23	15,000	95.3	47.2	64.5	3.86	1.15	1.34	1.38	1.04	2.18	2.33	2.06	2.04	6.8‡

* Cities of over 10,000 inhabitants only. † Cities up to 10,000, as well as the country population. ‡ Average of 14.

ested would do well to make similar studies for such places as Fall River and New Bedford, Mass., Lackawanna, N. Y., Paterson, N. J., Dickson City and Old Forge, Pa., Hamtramck, Mich., Chicago (especially the wards bordering the Chicago River and drainage canal), Cicero and Herrin, Ill., and the home counties of legislators who have introduced anti-evolution bills in various state legislatures since 1922.[6]

Some persons might not see much advantage in living in a community with a large proportion of females, adults and noted persons, and small families and little illiteracy, if they thought they could do just as much, or more, business in some other kind of place. But good government and freedom from crime are certainly worth having, and the reader will probably have difficulty in recalling any news of political scandals, strikes or crimes from any typical college town. Or if crimes are committed, they may be the work of invaders from less civilized communities, as is often the case in Evanston, on account of its proximity to Chicago. Another point worth considering is that the average of feminine pulchritude is almost certainly higher in cultured communities than it is elsewhere, though it may be impossible to prove that statistically in the present state of our knowledge.

In spite of all this, strange to say, there are "boosters" in many educational centers who would like nothing better than to get some new railroads, stores or factories, to increase the quantity of population regardless of quality, and thus sacrifice the future for a little "unearned increment" of property values, or a temporary increase in business.

One slight drawback to living in a college town should be conceded, however. Rents and commodity prices are sometimes, perhaps usually, a little higher in such places than elsewhere, though this may be only a reflection of the high standard of living. Within 150 miles of New York there is a small college town with 64.4 per cent. of adults and 3.97 persons per family (in 1920), about six miles from a larger manufacturing center with 60.5 per cent. of adults and 4.44 persons per family. In the latter place 27.1 per cent. of the total population are wage-earners (more than one per family), and the average wages in 1919 were $935 (as compared with $1,075 in the whole state). Prices of some kinds of merchandise are lower in the factory town, and some college professors who have automobiles take advantage of that fact and go over there to buy their groceries.

[6] "Middletown," the subject of a recent much-discussed book by Robert S. and Helen M. Lynd, is easily identified with the aid of a few census volumes, and is almost the antithesis of a college town in some respects, although it is the seat of a state normal school and has remarkably small families.

* Cities of over 10,000 inhabitants only. † Cities up to 10,000, as well as the country population. ‡ Average of 11

THE CLIMATIC FACTOR IN MAN'S PHYSICAL ENVIRONMENT

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MAN'S climatic environment affects him in many ways. His clothing, dwellings, food, occupations and customs; his physical and mental characteristics; his system of government; his migrations; his history—all are affected to a greater or less degree. The atmosphere is as essentially unalterable as it is all-pervading. Montesquieu declared that the most enduring of all empires is the empire of climate. "Its dominion is invincible. Its laws must be obeyed. It makes no compromise and it grants no pardon." We may irrigate a portion of the earth's surface and thus remove it partially from the dominion of its local climate, but we maintain this change only by unending effort. If left to itself, the desert will encroach upon the irrigated area. Ancient cities which have been buried in the sands of the desert are evidences of the dominion of climate, rather than of the destruction accomplished by man. Man often thinks that he is conquering nature when he really merely discovers her laws and conforms to them. We have learned to adjust ourselves to some extent to our climates, but we can not change those climates.

It is natural that, even from the earlier days of classical writing, emphasis was laid upon the importance of climate in controlling man's activities, and especially in determining many of his characteristics. The ancients believed in direct and immediate effects of weather and climate upon disease. Similarly, they believed in direct effects of atmospheric conditions upon man's physical traits and upon his character.

Early views on climatic environment.[1] In his treatise "On Airs, Waters and Places," Hippocrates made what appears to have been the first serious attempt to correlate racial and social types with differences in physical environment. In comparing Europeans with the inhabitants of Asia, he says that

> the former are of great variety, vigor and fierceness, while the latter are known for their equable and gentle dispositions. These qualities are in agreement with the rapidly changing seasons of Europe on the one hand and the mildness and uniformity of the Asiatic climates on the other. To develop vigor and bravery, a climate is needed which will excite the mind, ruffle the temper and demand fortitude and exertion.

Europe, he believed, had a variety of people because it has a variety of climates, while Asia, where he considered the climate much more uniform, had uniformity of population.

Aristotle made an interesting point on the influence of climate on government. The people who live in the cold climate of northern Europe, he said, are conspicuous for their spirit, but their lack of intelligence makes them unsuitable for political organization. Asiatic peoples, on the other hand, have intelligence and inventiveness but lack spirit and are content to remain in subjection. The Greeks, intermediate in position, were held to combine the advantages of both extremes without their disadvantages, and were therefore, in Aristotle's opinion, the best-governed people and naturally fitted to rule the earth.

In his "History of Rome," the Greek historian Polybius, with keen insight, suggested the possibility of overcoming the detrimental influences of climate

[1] In the following paragraphs on the views of the ancients, the writer has drawn very freely on Professor Franklin Thomas's "The Environmental Basis of Society," New York and London. The Century Company. 1925.

upon national character by education and discipline. He gave as follows the reasons for the introduction of music into Arcadia:

> They saw that Arcadia was a nation of workers; that the life of the people was laborious and hard; that as a natural consequence of coldness and gloom, which were the prevailing factors of a great part of the country, the general character of the people was austere . . . and it was with a view of softening and tempering this natural ruggedness and rusticity that they introduced the things which I have mentioned.

The most extensive discussion by a Roman author of the influences of climate upon the mental and physical characteristics of a people is found, curiously enough, in the work of a writer on architecture, Vitruvius. The men of the north, he says, "are helpless in the face of fevers or great heat, but are brave in war because of their large supply of blood." Men of the far south living under the direct rays of the sun "have too much moisture drawn out of their systems and hence have little blood." They can easily endure fever and heat, but are timid in battle. They are of lower stature than northern peoples; have a swarthy complexion, curly hair, black eyes, strong legs and little blood. Southern peoples have a keen intelligence because of the rarity of their atmosphere and the heat. Northern peoples who live in a dense atmosphere are "chilled by moisture from the surrounding air, and have but a sluggish intelligence." He illustrates this point by calling attention to the activity of snakes in warm weather as contrasted with their torpor in cold weather. People who live in cold countries are physically better equipped for fighting, but their courage is not intelligent and they are likely to lose through their lack of judgment. The conditions which produce the best races are intermediate between these extremes, and Vitruvius uses as his illustration the region occupied by the Romans. It will be observed that Aristotle thought that the superior people were located a little farther south, namely, in Greece. The "line of racial superiority" was thus moved in accordance with the nationality of the writer.

Pliny wrote:

> There can be no doubt that the Ethiopians are scorched by their vicinity to the sun's heat, and they are born, like persons who have been burned, with the beard and hair frizzled; while, in the opposite and frozen parts of the earth, there are nations with white skins and long light hair. The latter are savage from the inclemency of the climate, while the former are dull from its variableness. . . . In the middle of the earth there is a salutary mixture of the two, a tract fruitful in all things, the habits of the body holding a mean between the two, with a proper tempering of colors; the manners of the people are gentle, the intellect clear, the genius fertile and capable of comprehending every part of nature. They have formed empires, which has never been done by the remote nations, yet these latter have never been subjected by the former, being severed from them and remaining solitary, from the effect produced on them by their savage nature.

"The middle of the earth" doubtless referred to Rome.

Galen, the great medical writer, believed that "a cold climate would aid the progress of a disease caused by cooling of the elements, and prevent one caused by heating of the elements." The same ideas were held to apply to hot, dry and wet climates. In general, Galen followed the theories of Hippocrates.

These extracts must suffice to indicate the general trend of thought among ancient writers in regard to the direct effects of climate upon man. Mention of a considerable group of the medieval writers must be omitted for lack of time, and we must pass at once to Montesquieu (1689–1755). In "The Spirit of Laws" there are numerous interesting references to the importance of the climatic factor in man's environment. Montesquieu held that the people in cold countries "tend to be brave, vigorous, insensible to pain, and are possessed of strong physique and of phlegmatic tem-

peraments." On the other hand, those who live in warm climates "are weak, timid, opposed to physical exertion, vivacious, sensitive to pleasure or pain, and are lacking in mental ambition." If the climate makes people stubborn, the laws are tyrannical. On the other hand, if the climate makes them gentle, the laws are liberal. Political conditions, Montesquieu believed, are also markedly influenced by climate. Northern peoples, stronger and more vigorous than those of the south, are easy conquerors in warfare. Therefore, where a warm country adjoins a colder one, the former will be conquered and ruled by the latter.

Intemperance, in Montesquieu's view, increases with the cold and dampness of the climate and with distance from the equator. In hot countries the loss of moisture through perspiration must be offset by drinking a great deal of water; in cold climates, on the other hand, spirituous liquors are necessary in order to prevent the blood from congealing. Montesquieu also maintained that climate has a decided influence on domestic and conjugal relations. In warm countries women mature earlier; they are less wise than their husbands and are naturally inferior in status. By reason of this fact, together with the low cost of living and an excess of females in warm countries, polygamy is common there, while monogamy prevails in cold countries. This condition prevented the progress of Mohammedanism in cool countries and of Christianity in warm latitudes.

Buffon held that man was originally of one type and changed because of the effects of environment. Hence, if a negro were to return to a temperate climate he would in a few generations become white again. Herder wrote: "We are ductile clay in the hand of climate," and believed that, while climate can not change the species, it can cause variations within the species which are transmissible through heredity. Von Humboldt held to the view, which was advanced long before his time, that the temperate zone is best suited to man's intellectual development and to his control over the forces of nature. Adam Ferguson, in his "History of Civil Society," maintained that in cold climates people "are dull and slow, moderate in their desires, regular and pacific in their manner of life," while in warm climates they are "feverish in their passions, weak in their judgments and addicted by temperament to animal pleasures."

Some modern views regarding climatic environment. Among modern writers Friedrich Ratzel, whose work has become well known to English and American readers through the writings of Miss Ellen C. Semple, has given the most thorough discussion on environmental influence. He believes that climate affects man directly through its influence on his physical and mental characteristics and indirectly through its effect upon his animal and vegetable food. In common with Aristotle, Ratzel maintains that temperate zone peoples are superior both from a political and military point of view. They are also more advanced in culture than the polar and equatorial zone people. In the temperate zones themselves, the people who live in the colder portions are superior to those who live in latitudes nearer the equator. He also holds that differences of climate in neighboring districts may be disadvantageous because they make political union more difficult. A general similarity of climate is conducive to economic uniformity and political unity. Buckle, in his "History of Civilization in England," stresses the effect of physical environment upon the human race. Climate, soil and food together determine the accumulation of wealth, and the accumulation of wealth must precede any high development of knowledge. There can, according to Buckle, be no leisure without wealth and no knowl-

edge without leisure. In the early stages of the accumulation of wealth, energy and the regularity of labor depend upon climate, and the returns of labor depend upon the fertility of the soil.

Guyot, in a passage which has become a classic in the literature of anthropogeography, wrote as follows:

> Since man is made to acquire the full possession and mastery of his faculties by toil, and by the exercise of all his energies, no climate could so well minister to his progress in this work as the climate of the temperate continents. It is easy to understand this. An excessive heat enfeebles man; it invites to repose and inaction. In the tropical regions the power of life in nature is carried to the highest degree; thus with the tropical man, the life of the body overmasters that of the soul; the physical instincts of our nature those of the higher faculties; passion, sentiment, imagination, predominate over intellect and reason; the passive faculties over the active faculties. . . . In the temperate climates all is activity, movement. The alternations of heat and cold, the changes of the seasons, a fresher and more bracing air, incite man to a constant struggle, to forethought, to the vigorous employment of all his faculties. . . . Thus, if the tropical continents have the wealth of nature, the temperate continents are the most perfectly organized for the development of man. They are opposed to each other, as the body and soul, as the inferior races and the superior races, as savage man and civilized man, as nature and history.

Dr. Ellsworth Huntington has written several volumes as well as a large number of shorter articles on climatic influences on man. He has studied the relations of various conditions of climate and weather to human efficiency and has determined what are the best climates for the maximum mental and physical activity. On the basis of these and other studies he has correlated the distribution of civilization and of climate and found a close coincidence between the highest civilization and the most favorable climate. Huntington believes that climate is the chief factor in determining health conditions and human activity; that as climates have fluctuated or varied in past times, nations and peoples have had epochs of great success and prosperity or have decayed; they were at peaks of prosperity and power when their climate was at its optimum; they declined when their climate was depressing. The number of factors concerned in such great epochs is so large, climate being only one of them, and the historical, biological and physiological reactions are so important, that some of the more conservative climatologists hesitate to follow Dr. Huntington to all the conclusions which he has reached.

Weakness of old views regarding effects of climate on man. It is easy to go too far in calling upon climate to explain phenomena which we may otherwise find it difficult to account for. This was the mistake formerly made by most of the writers on this subject. Thus Gervase of Tilbury, in the thirteenth century, said that "according to the diversity of the air the Romans are grave, the Greeks fickle and unreliable, the Africans sly and crafty, the Gauls fierce and the English and Teutons powerful and robust." The same writer held that the violent mistral blowing in the Rhône Valley generates in this region men who are windy, empty-headed, inconsistent and untrustworthy. Another writer of the middle ages, Otto of Freising, suggested that the Lombards who settled in Italy lost their ferocity largely on account of marrying Italian women, but also partly because of the nature of the country and the climate. Maupertuis and others held that the color of man's skin becomes paler with increasing distance from the equator. Livingstone wrote that in Africa religious ideas seemed to depend upon distance from the equator. One writer held that cold produces a small stature; another believed that the pygmies are small because of the heavy seasonal rains which fall in hot equatorial Africa. Climate was believed to explain the overhanging eyebrows and partly closed eyes of the Negro, the small eyes and beardless faces of the Chinese, the supposed fact

that more twins were born in Egypt than elsewhere, and so on. The broad generalizations of Montesquieu, Voltaire, Buffon, Hume, Buckle and others furnish interesting reading and contain much that is suggestive and instructive, but they usually carry us well beyond the range of reasonable probability.

In looking through the extensive literature on the influence of environment, it is perfectly clear that the dominant view of the earlier writers, even down to the time of Buckle, was that environment acts directly and immediately upon the individual, not only upon his physical characteristics but also upon his mental traits and his character. Montesquieu, for example, as we have seen, held that a direct correlation exists between climate and mental traits. Finding themselves face to face with many puzzling facts, difficult of explanation, the ancient writers, as so often happened in the early days of science, seized upon one general blanket theory—the influence of climate—and attributed to that one cause the highly complex series of facts which they could not otherwise clear up. While such broad views have now generally been rejected, several more recent writers hold that weather conditions temporarily affect the habits and characteristics of individuals, and therefore react upon the characteristics of the group as a whole.

In his very significant essay, "The Pacific Coast: a Psychological Study of the Relations of Climate and Civilization," the late Professor Josiah Royce, of Harvard, clearly expressed his views on this matter as follows:

> The outer aspect of nature unquestionably molds both the emotions and customs of mankind, insensibly affects men's temperaments in ways which, as we know, somehow or other tend to become hereditary, however we may view the vexed question concerning the heredity of acquired characters. . . . The tendencies of the moment are in their way indications of what the tendencies of the ages are to be. . . . In the case of such a climate as the one of California, your relations with nature are essentially intimate, whether a student of nature or not. . . . This intimacy with nature means a certain change in your relations to your fellow men. You get a sense of power from these wide views, a habit of personal independence from the contemplation of a world that the eye seems to own. . . . The California proprietor can have, during the drought, more leisure unless, indeed, his ambition for wealth too much engrosses him. . . . In California the more regular routine of wet and dry seasons modifies and renders more stable the general psychological consequences. All this is encouraging to a kind of harmonious individuality that already tends in the best instances toward a somewhat Hellenic type. . . . In California, unless you are afraid of the rain, nature welcomes you at almost any time. The union of the man and the visible universe is free; is entirely unchecked by any hostility on the part of nature, and is such as easily fills one's mind with a wealth of warm experience . . . not the relation of hostility but of closeness. And this is the sort of closeness determined not merely by mild weather, but by long drought and by the relative steadiness of all the climatic conditions. . . . Individuality, then, but of a peculiar type, and a tendency despite all this individualism toward agricultural conservatism and a definite social organization—these are already the results of the climate.

A recent writer has said, "The modification of animals and of plants under direct or indirect climatic controls naturally prejudices us in favor of the belief in similar modifications in man himself. There is, however, little reliable evidence in favor of such a view, however strong the probability may appear to be. We are nowadays somewhat skeptical about attributing to climate immediate and direct effects upon the mental and physical characteristics of man, individually and racially." Professor Franklin Thomas writes: "Modern social scientists, as a rule, are coming to regard geographic factors more as conditioning influences than as determinants, and to hold that man and culture, primarily, are the dynamic and determining factors." Or, as another has expressed it, "The environment furnishes the builders of cultural structures with brick and mortar but it does not furnish the architect's plan." What-

ever weight may be given to climate alone, as distinguished from the influence of the physical and the psychical environment, it is certain that climate must always be a factor. "The physical environment always includes climate."

Into the controversy as to the relative weight to be attached to climate on the one hand and the psychical element on the other I have no desire to enter. There are three general types of view in this matter. The first holds that environment is all-controlling; the second, that environment counts for little because the psychical element dominates mankind after the primitive ages are past; the third, that environment is an important factor to which a varying degree of influence is always to be ascribed. It seems to me that we may best illustrate the situation by means of a very simple formula, E + x, in which E is the environment, including climate, and x is man, *i.e.*, the psychical element. The controversy centers about the relative sizes of E and of x. Those who give increased weight to the environment naturally write the E large, and those who consider the psychical element more important increase the size of the x. Obviously the problem is a very difficult one because so many factors are involved in it. No simple and satisfactory solution is possible because the present state of science will not permit us to attempt any definition or any measure of the influence of climate upon the human race and its accomplishments or upon individual man. A great deal has been written as to the dominant influence of climate which is highly unsound and exaggerated beyond all bounds of reason. On the other hand, it is equally true that climatic influences are all-pervasive. It is the general view of the more recent writers that the environment has its maximum influence in the case of primitive man, and that, with the advance of civilization, the part played by the psychological and cultural factors becomes increasingly important. The more intelligent and the more highly civilized man becomes, the less he is at the mercy of his climate and the more he contrives to protect himself against it and to avoid the unfavorable elements in it. Man thus learns to adjust himself to his climate. He accomplishes what has been termed a "conditional conquest." He can not change his atmospheric surroundings, certainly not in any large way. He can never really "master his climate." He can tolerate it, he can not be independent of it. His habits are largely controlled by it. Hence it is true that "men seldom change their climate because to do so they must change their habits."

The more complex the development of human society; the more the different parts of the world are linked together; the more dependent nations become upon food supplies from other countries, the more direct and far-reaching the effects of weather and of climate inevitably must be. A disastrous drought involving a partial failure of the wheat crop in Argentina or in Canada reacts unfavorably upon the British Isles. A reduction of the cotton crop in the United States by frost affects the world's markets. A flood in China, accompanied by great loss of life, diminishes the demand for imported goods there. A serious deficiency of rainfall in Australia and lack of pasturage for cattle increases the price of beef and mutton exported from there to other countries.

Factors in the problem other than climate. To most of the older writers climate meant more than it does to-day. It included much of what is now termed our whole physical environment. Moreover, they based their conclusions upon incomplete records covering far too short periods of time. It must be remembered that we are dealing here with large, important, highly complex phenomena. Man moves readily from place to place, from climate to climate. His food,

drink, habits, occupations, to some extent his physical and mental characteristics, change in consequence. Inheritance, intermarriage, environment, opportunities, soil and many other factors enter in to determine what changes individual man and the race as a whole shall undergo. Time is a very important element in the final result, for in time a gradual adaptation to new conditions takes place. Climate is but one of many controls, albeit a most important one, for it largely determines what many of the other factors, such as diet, customs and occupations, for example, shall be. The task of giving climate its proper place as a factor controlling the life of man as a whole is a difficult one which can not be definitely and satisfactorily solved today, or to-morrow.

Climate and habitability. Climate determines both how and where man shall live. It classifies the earth's surface for us into the so-called habitable and uninhabitable regions. The desert of sand and the desert of snow and ice, whether the latter be near sea-level or high up on mountain tops, are alike climatic: the former because of aridity; the latter because of cold. The only non-climatic deserts are recent lava flows. Where a soil is present which is not frozen for much over half the year and where there is reasonable temperature and sufficient rainfall, plants and animals are found, ranging from few and lowly forms where conditions are the hardest and where all organic life is especially adapted to these conditions, to the greatest abundance where conditions are most favorable.

Man is influenced by much the same controls as those which affect plants and the lower animals. From the highest latitudes he is excluded by cold. The high altitudes are hostile both because of cold and because of diminished pressure. The deserts of sand are all thinly populated by reason of aridity. Forests, where rainfall is abundant, are unfavorable to a dense population. The trees must be cleared away before settlement is easy. Man is widely distributed over the earth's surface. In his migrations he has carried with him, beyond their original limits, many plants and animals. But the life of man is harder here and easier there according to climatic conditions and the scarcity or abundance of plant and animal life.

Man is distributed in great belts around the world corresponding roughly to the broad zones of vegetation, desert, steppe and forest, the limits of which are set by temperature and rainfall. But man is much more dependent on rainfall than upon temperature. Water he must have, either directly from the clouds or indirectly from rivers, springs or wells, or from melted snow and ice. There are certain common conditions of life which affect the people who live in the same zone in the same broad, general way, just as these zones have similar general conditions of winds and rainfall. This, Ratzel has pointed out, means that there is a climatic factor at work to maintain differences between the people of different zones in spite of the great movements which are constantly tending to produce uniformity. Obviously, the differences in the life of man which depend upon climate will be most noticeable and will be likely to have the greatest historical significance when marked contrasts of climate are found close together, as in the case of mountain ranges like the Alps, or of a pronounced lowland, plateau and mountain topography like that of Peru or Mexico. All the regions of sparse population are gradually being encroached upon by invasion from their borders. Forests are being cleared and replaced by open agricultural lands. Wheat and corn are replacing grass in the steppes and savannas where irrigation can be practiced. Deserts are being reclaimed for farming here and there where water is avaiable, and the more civilized man becomes, the

denser the population which the different parts of the earth can be made to support. It is the story of a more complete to a less complete mastery of man by his environment, but in spite of all that man can do, the large climatic limitations persist. The Greenland desert of snow and ice and the Sahara desert of sand must remain practically deserted.

Australia, Madagascar and South Africa have the bulk of their population on the east, where the rainfall is most abundant. To the westward, there is a rapid decrease both in rainfall and in population. In the interior of the United States, the population diminishes rapidly to the westward of the one hundredth meridian, where the critical rainfall boundary of twenty inches is reached. The distribution of population along the Pacific coasts of the two Americas is a direct response to the rainfall or to irrigation. Europe is favored in having but limited areas which suffer from deficient rainfall. The interior and southeast of the Spanish peninsula and the steppes of eastern Russia have a restricted population because of the deficiency of rainfall. Russia's population "leans westward," as Professor Mark Jefferson has expressed it, towards the heavier rainfall, but the population of the Iberian Peninsula is marginal in agreement with the distribution of its rainfall. Australia is largely a trade wind desert; the eastern border has the most favorable rainfall, and it is there that the present and the future population must chiefly settle. Over most of the United States west of the one hundredth meridian, except in irrigated districts and on the Pacific Coast, and in the interior and western parts of Asia, the population will always be thin. There is not enough water in either of these great areas for any considerable increase in irrigation. Extreme cold and aridity prevent the cultivation of the soil in the far north and therefore inevitably limit the population and prevent or retard economic and social development.

If we look about the world to-day we find that the general state of civilization is markedly influenced by precipitation. Temperature also plays a very large part in determining the growth of natural vegetation and of crops, but the most obvious control—the one that is most striking in a climatic survey—is rainfall. In wet forests we find hunters who live an uncertain and impoverished existence. Deserts and dry steppes produce nomads who give up their lives to fighting and robbery. In intermediate climates farming is the dominant occupation; the people are peaceful and eventually develop stable governments. When arid lands are irrigated the nomadic population is replaced by a sedentary people, occupied in agricultural pursuits. It is in such regions that the origin of civilization is to be sought.

Primitive civilization and the tropics. It has been generally thought that man in his earliest stages, when most helpless, was an inhabitant of the tropics; that he lived in the mild, uniform, genial climate of that zone where food was easily obtained and protection against the inclemencies of the weather least necessary.

The recent investigations in the deserts of Central Asia have been turning many people's thoughts in that direction as the region of man's very early habitation. In the far distant past, on the border-zone between the last Ice Age and what we may call, in a rather loose way, historical times, Central Asia seems to have been a land of sufficient rainfall while most of northern Europe and of North America was ice-covered. Glacial periods were times of more precipitation, as well as of somewhat lower temperatures. With the change to climates essentially like those of to-day, there was a change to less rainfall, as well as to a slightly higher temperature. This

transition was a gradual one, probably with oscillations extending over long intervals of time.

The earliest civilizations seem to have developed in arid climates or on their margins—in the ancient Orient, Mesopotamia, parts of India, the interior of China and Egypt. In the western hemisphere, the Peruvian, Mexican and Pueblo cultures were developed under fairly similar conditions. The conditions for the development of these civilizations were found in irrigation, which insures abundant and regular crops as long as man leads a well-organized community life and does not relax his labors. In these irrigated localities lived races more energetic and more hardy than those of the damper and rainier portions of the tropics where vegetation was more luxuriant. Civilization was probably first developed, not where the overwhelming superabundance of nature's gifts seems to offer the best conditions, but where man was under some stress of labor, some spur to effort, in less favorable natural conditions, but such as developed him.

The nations living at ease on the tropical lowlands were naturally, from early days, the object of frequent attacks and invasions at the hands of the more active and more warlike races living in more rigorous climates farther north, or at greater altitudes on mountains or plateaus. The invading tribes, having in time become enervated by an easy existence on the warm lowlands, were themselves often later overcome by new enemies from the north. Some of the greatest migratory movements in history have taken place from colder to warmer climates, as part of this general equatorward tendency in both temperate and tropical zones. The barbarous tribes broke through the northern passes and descended onto the more genial and more fruitful lowlands of India, being helped to do this by the ease of the descent. Such mountain systems as the Himalayas, or the Alps, stretching east and west, are natural climatic divides between more genial and more severe climates, and have often been crossed by invading armies from the north. The descent of the Aryans into India, the Manchurian conquest of China, the invasion of Greece and Italy from the north, the southward movement of Toltecs and Aztecs in Mexico—all have been cited as illustrations of this equatorward tendency. Sir Flinders Petrie in his "The Revolutions of Civilizations," has said:

> There is no advancing without strife. Man must strive with nature or with man, if he is not to fall back and degenerate. The harder and longer a nation strives the more capable it will be. This is not only the slow result of selection, but it is the immediate result in each individual produced by the attitude of his mind. The northern nations, accustomed to striving against climate, thrive vastly when they get into easier countries until their tone is let down to their conditions.

Geographical march of history. A gradual migration of the center of civilization away from the tropics and the highest development of the human race not where life is easiest but in extra-tropical latitudes are significant. Herbert Spencer clearly stated his view that the geographical march of history has been a steady progression from the warmer and more productive regions necessary in the feebler stages of social evolution to the colder, less productive and more difficult regions away from the tropics. He wrote as follows:

> I do not ignore the fact that in recent times societies have evolved most, both in size and complexity, in temperate regions. I simply join with this fact that the first considerable societies arose, and the primary stages of social development were reached, in hot climates. The truth would seem to be that the earlier phases of progress had to be passed through where the resistance offered by inorganic conditions was least; and when the arts of life had been advanced, it became possible for societies to develop in regions where the resistance was greater; and that further developments in the arts of life, with the further discipline in co-

operation accompanying them, enabled subsequent societies to develop, to take root and grow in regions which, by climatic and other conditions, offered relatively great resistances.

The focus of culture shifted from the ancient Orient to Greece, and Greece was succeeded by Rome. From the Mediterranean region, therefore, where the world's civilization, its commerce and its power were long centered, westward through Spain and Portugal, the migration continued farther and farther north until Holland and then England became the dominant power. From lands of more genial climates, rich in natural products, to lands of colder and longer winters, the migration has taken place. The advance of Christianity, from its origin in the subtropical belt of Eurasia into higher latitudes, has been pointed to as another illustration of the same tendency. Together with this northward tendency of civilization there has run through the past an equatorward movement, already noted in the case of the tropics, of the stronger peoples of the north toward the milder and more genial southern latitudes, involving historical events of great importance.

As Guyot summarized the geographical march of history and of civilization:

> The man of the Old World sets out upon his way. Leaving the highlands of Asia, he descends from station to station towards Europe. Each of his steps is marked by a new civilization superior to the preceding, by a greater power of development. Arrived at the Atlantic, he pauses on the shore of this unknown ocean, the bounds of which he knows not, and returns upon his footprints for an instant. Under the influence of the soil of Europe, so richly organized, he works out slowly the numerous germs wherewith he is endowed. After this long and teeming repose, his faculties are reawakened; he is reanimated. At the close of the fifteenth century, an unaccustomed movement agitates and vexes him from one end of the continent to the other. He has tilled the impoverished soil, and yet the number of his offspring increases. He turns his look at once toward the east and the west, and sets out in search of new countries. His horizon enlarges; his activity preys upon him; he breaks his bounds . . . he abandons himself to the winds and the currents, which bear him gently towards the coast of America. He is enraptured as he treads the shore of this land of wonders, still more adorned in his eyes by all the fascinations his ardent imagination lends it.

Köppen makes the interesting suggestion that in the future there will be a gradual return to the irrigated regions of the subtropics where agriculture can be carried on under more favorable conditions. Thus, in his words,

> The development which has led mankind from Babylon to London has in certain respects probably gone too far. On the one hand, it may be observed that too exclusive a concentration upon industry and trade in any country carries with it great changes, and, on the other, with the aid of modern science and technical skill, we are again going to practice agriculture under irrigation in conditions of uncertain rainfall. Thus the warm and sunny lands will regain some of the advantages which they have lost to the colder and damper climates, precisely in proportion to the degree with which man's scientific and technical skill succeeds in overcoming the difficulties of transportation and in mastering tropical diseases.

In his "Manual of Meteorology," Sir Napier Shaw has clearly stated his view in regard to the movement of civilization from its ancient centers to northern and apparently much less favorable climates. He writes,

> According to the teaching of the new anthropology, human civilization was autochthonous in ancient Egypt, and spread from there over the world with subsequent subcenters of diffusion in Babylon and India. This view may not be accepted, but it arrests attention by the circumstance that Egypt, and especially the Egypt of the early Egyptians, is that part of the world which is most nearly independent of what we understand by weather. It draws its water supplies from the river and takes nothing but dew from the sky. It has winds generally so arranged as to temper and mollify the burning effect of the sun's heat, seldom strong enough to raise a dust-storm, and practically free from the terrible visitation known as simoom. At the same time it is wonderfully fertile with very little effort on the part of the husbandman. If then our civilization began in Egypt, we are faced with the conclusion that primitive man found the line of least resistance to his advance towards civilization in a country which has no weather, and yet enjoys a plentiful supply of water, with a sky so serene and genial as to make

clothing a matter of little importance and the indispensable shelter . . . an easy artifice. . . . Although the localities of genial climate, plenty of water and no weather are the easiest for human beings to live together in, they are apparently not the best in the long run. The civilizations that spread out from the original centers, carrying with them the contrivances for their own protection and enrichment that had been invented in the favorable locality, developed faster when they faced the vagaries of a weather-climate. Though we may trace the dawn of civilization to the country where cyclonic depressions are practically unknown, we must look upon the region of the maximum number of cyclonic depressions as the most favorable for the development of human energy.

Climate and man in the temperate zone. Intermediate in location, in mean temperature and in their physiological effects, the temperate zones, whatever was the condition in the past, are to-day clearly the center of the world's civilization, as they have also been the scenes of the most important historical developments for several centuries. From the temperate zones have come the explorers and adventurers of the past and are coming the exploiters and colonizers of to-day. In the occurrence of the temperate zone seasons lies much of the secret—who can say how much of it?—of the energy, ambition, self-reliance, industry, thrift, of the inhabitant of that zone. Guyot did not exaggerate when he wrote:

> In the temperate zones all is activity, movement. The alternations of heat and cold, the changes of the seasons, a fresher and more bracing air incite man to a constant struggle, to forethought, to the vigorous employment of all his faculties. A more economical nature yields nothing except to the sweat of his brow; every gift on her part is a recompense for effort on his. . . . Invited to labor by everything around him, he soon finds, in the exercise of all his faculties, at once progress and well-being.

The monotonous heat of the tropics and the continued cold of the polar zones are both depressing. Their tendency is to operate against man's highest development. The seasonal changes of the temperate zones stimulate man to activity. They develop him physically and mentally. A cold, stormy winter necessitates forethought in the preparation of clothing, food and shelter during the summer. Carefully planned, steady, hard labor is the price of living in these zones. Development must result from such conditions. In the warm moist tropics life is too easy. In the cold polar zones it is too hard. Temperate zone man can bring in what he desires of polar and tropical products, and himself raises what he needs in the great variety of climates of the intermediate latitudes. Near the poles the growing season is too short. In the moist tropics it is so long that there is little inducement to labor at any special time. The regularity and the need of outdoor work during a part of the year are important factors in the development of man in the temperate zones. Where work is a universal necessity, labor becomes dignified, well-paid, intelligent, independent.

Behind our civilization there lies what has been well called a "climatic discipline"—the discipline of a cool season which refreshes and stimulates, both physically and mentally, and prevents the deadening effect of continued heat. On the other hand, a very long winter is about as unfavorable as a very long summer. If outdoor work is seriously interrupted, progress is retarded. Buckle based certain too broad generalizations on this consideration, and saw in it an explanation of similar national characteristics among peoples whose outdoor work is interrupted for the same length of time. But it is clear that the length of the farming season is a large factor in controlling the return from the soil, the kind of work done and the manner of doing it. It is not surprising to learn that the difficulty of keeping farm laborers through the long winter has been a handicap in western Canada, and that it was urged against the abolition of slaves in Russia that it would be im-

possible, without some form of compulsion, to keep farm-hands during the winter. A recent writer has pointed out that the winter climate of Canada has been perhaps the most favorable asset that that country can have. The severity of the climate, except on a small part of the Pacific coast, has eliminated the Negro question, which, he says, "weighs like a troublesome nightmare upon the civilization of the United States, which shadows the future of South America and gives many anxieties to Australia." This cold has also kept away the peoples of southern Europe who do not readily assimilate with the Anglo-Saxon stock, and has attracted the hardier immigrants from northern Europe.

The available evidence, both theoretical and as based upon history and human experience, indicates that man makes his best progress where he is forced by natural conditions of seasonal change to take thought for to-morrow, provided he also has time for the development of ideas. Agriculture, with the settled life which that occupation involves, usually provides such favorable conditions. Man must study the seasons. He must take thought for the future. He must, as population increases, widen the area under culture. He may have to irrigate. He becomes a thinking, planning and inventive creature. He develops his body and his mind. No writer has expressed more vigorously or more picturesquely the development of man and his conquests of the earth than has Dr. David Starr Jordan in the following striking lines:

> The strong races were born of hard times; they have fought for all they have had, and the strength of those they have conquered has entered into their wills. They have been selected by competition and sifted by the elements. They have risen through struggle, and they have gained through mutual help, and by the power of the human will they have made the earth their own.

Present-day migrations within the temperate zone. Within the north temperate zone especially, and also across from the north to the south temperate, vast, peaceful migrations are taking place, determined to a considerable degree by climatic considerations. From Europe and Asia to the United States alone, millions of people have migrated, and they are still coming. These immigrants have shown marked tendencies to settle where climate, soil and occupations are most like those of their old homes, although the fact that most of them land at one or two ports on the eastern seaboard, the concentration of industry in certain sections and other controls have operated very effectively to counteract and interfere with this tendency. Scandinavians, for example, have gone largely into the northwest; in the future the southern parts of the United States will probably have a much larger Latin population, who will there find homes and occupations in climates best suited to their needs. It is an undoubted fact that the large colored population in the south, the result of the importation of slave labor to do work which the whites found themselves unable or unwilling to do, has been an important factor in checking the movement of recent European immigrants into the southern states. This is one reason why the white population of the south is still so essentially Anglo-Saxon and homogeneous, while the north has become a great complex of diverse nationalities and tongues. Canada has grown slowly, partly on account of the repelling effect of her long, cold winters and her generally severe climate. Of late years, however, the rapid settlement of farming lands in the United States, the attraction of free, or cheap, lands in western Canada and the success which has been attained in raising wheat and other crops during the short but favorable Canadian summer have combined to induce a considerably increased immigration of farmers from the United States and of north Europeans into

Canada. Present-day migrations within the temperate zone are peopling Canada, South Africa and Australia with the same stock that occupies the homeland of the British Isles. Therefore institutions and government essentially similar to those at home are possible in these lands. The case is very different in tropical climates.

In Argentina, the climatic control of migrations is even more clearly marked than in the United States, the Italians tending to settle towards the north, where the climate is most like their own, while the races from northern Europe show a tendency towards the south. Many Italians take advantge of the differences in seasons in the northern and southern hemispheres and do two seasons of summer work each year, one on each side of the equator. It is interesting to observe how immediately controlled by the special weather conditions of even one season these voluntary migrations may be. Years of sufficient rainfall and abundant crops in the United States were usually followed by a larger immigration, that is, before the present policy of limited immigration was established. A failure of crops in Europe, whether of wheat in one country or of fruit in another or of potatoes in another, resulting from drought or storms or excessive rainfall, is always likely to promote a larger exodus from the country concerned. There is, furthermore, a considerable seasonal migration across the Atlantic. Many Italians have come to the United States in the spring to work during the warmer months, when farm and outdoor laborers are in demand, and have returned to the milder climate of Italy for the winter.

The continents and the temperate zone. Europe is well situated climatically, being almost altogether in the temperate zone and open to the ocean on the west, so that nearly all parts of it are well watered. Asia is an overgrown country. Much of it is in the temperate zone, it is true, but the interior is so far from the sea that the climate is severe and the rainfall very deficient. This condition of hopeless aridity is depressing in the extreme, and this region is prevented from becoming thickly populated or important on that account. Most of Africa is within the tropics. Its plateaus will furnish considerable areas not wholly unfavorable for white settlement. The southern part of Africa is just within the marginal subtropical belt of the south temperate zone. The same is true of Australia. South America is widest within the tropics. Its west coast is peculiar in having the tempering influence of high plateaus in the interior and of a cool ocean current along the coast. Its southern portion tapers off into the south temperate zone. The narrowing of Africa and of South America toward the south results in providing a comparatively limited area of well-watered plains for future settlement. North America is widest in the temperate zone, and this is one of its greatest assets. It suffers from the extreme cold of its winters in the north and from the rain-shadow effect of its western mountains, which gives the interior basin and part of the western plains a deficient precipitation.

Differences between northerners and southerners. There are certain broad, distinguishing characteristics of man in the temperate and tropical zones, in determining which it is reasonable to believe that climate has played a part. Similarly, there has been a natural tendency to attribute certain differences between northerners and southerners in the temperate zones themselves to a difference in climate. The former, living in a duller, harsher climate, with long dreary winters, are more serious, more industrious, more enterprising and act after more mature deliberation than the latter who, reflecting their brighter skies, are more cheerful, more kindly, more impulsive, more genial, more gen-

erous and also less energetic and more easy-going. The northerner must exercise more forethought, care, industry and prudence; he has to work harder and is usually better paid than the southerner. These national differences are proverbial between northern and southern Germans, French, Spanish, Russians, Italians, Arabs and other peoples. The influence of climate has likewise been traced in the sad, even pessimistic tone of much of the northern literature, and in the gravity and melancholy of modern northern music as well as of the northern folk-songs. Mr. John Masefield has written a very suggestive comment on English poetry.

> Because poetry is an art of the sun and because poets are inspired according to their degree of light, I can not declare that our English poets are the best the world has ever known. We have not a terrible climate . . . therefore our art is not terrible. Neither have we the bleakness of Spain which produces a severe art, nor the gentle climate of Italy which makes the art of Italy so gracious, and we have not the clear climate of France, which makes the art of France just. . . . We have a temperate climate, and therefore a temperate art. Our poets are not likely to go to either extreme.

In regard to the sadness and melancholy of the Russian peasant, a Russian writer has said:

> During the long winter months when the climate is most rigorous, a large part of the Russian population is undernourished. In the autumn it rains for weeks in succession. The steppes are gray and monotonous. Dismal forests stretch over hundreds of miles. All these conditions communicate themselves to the underfed brain, which imperceptibly passes over into a brooding melancholy that crushes the individual like a nightmare, filling him with dead inertia and hopeless resignation.

Sir Archibald Geikie, in his "Scottish Reminiscences," has emphasized the climatic influence in producing the grim character of the Scot in the following words:

> The gloom of his valleys is deepened by the canopy of cloud which for so large a portion of the year rests upon the mountain ridges and cuts off the light and heat of the sun. Hence his harvests are often thrown into the late autumn, and in many a season his thin and scanty crops rot on the ground, leaving him face to face with starvation and an inclement winter. Under these adverse circumstances, he could hardly fail to become more or less subdued and grim.

This whole question of racial characteristics and differences is a highly complex one, controlled by many variable factors. Climate is one factor out of the many. That it plays a part, often a significant part, in the final result can not be doubted. The fascinating element in the whole discussion is the effort to determine, quantitatively, the value of the climatic factor. And this determination, in the present stage of human knowledge, seems impossible.

DR. THOMAS HUNT MORGAN

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE PROGRESS OF SCIENCE

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT DES MOINES

THE very successful Des Moines meeting was one of those coming in alternate years which are intended to carry the work of the association to a new or more remote center, in order that the good news of science may be spread and scientific men may have opportunity to learn about all parts of the country. The association meets once in four years successively in New York, Chicago and Washington, when most of the associated societies come together. These are also the times of the quadrennial national elections and it may ultimately be recognized that the scientific meetings are national events of the same order of magnitude, for the advancement of science is more important for the national welfare than which political party is in office.

At the intervening two-year periods the meeting is in a large and accessible city; last time it was in Philadelphia, next year's meeting will be in Cleveland. Then in the alternate years the association migrates to cities that may be distant from the main scientific centers and of such size that a very large meeting could not be cared for. The meeting two years ago was at Nashville; it was expected that the meeting two years hence would be at New Orleans. At the recent Des Moines meeting the plans of the Chicago "Century of Progress" Exposition of 1933 were presented and it was decided to hold the Chicago convocation week meeting in the summer instead of at Christmas time in order that there may be cooperation with the exposition, at which science is to be made the dominant feature, and with the international congresses that are planned.

It will be remembered that the American Association formerly held its meetings in the summer, as the British Association has always done. Transfer to the winter was made largely because this was the preference of most of the affiliated societies. The country, however, is so large and the number of its scientific men has increased so greatly—the association now has over 18,000 members—that there is urgent need of two meetings a year. The distance to the Pacific coast has led to the organization of a Pacific Division which holds summer meetings; it is desirable that these meetings, or some of them, be national meetings of the whole association. There will consequently be a summer meeting at Los Angeles and Pasadena in 1931; if this and the Chicago meeting are as successful as is expected, there will be regular summer meetings, alternating probably between the east and the west.

Des Moines may seem remote to those living on the Atlantic seaboard, but Iowa, Missouri and Kansas now have the largest birthrate of scientific men and the scientific population of the central states is very large. There were no fewer than 1,500 papers presented before the fifteen sections of the association and the some twenty-five special societies meeting in cooperation with them. Scientific research, even such as is highly specialized, was thus fully represented.

The second object of the association—the diffusion of science and the scientific method and the maintenance of helpful relations between scientific workers and the larger public—was forwarded at Des Moines to an unusual degree. There were more general and popular lectures than at any previous meeting. The press service, under Dr. Austin H. Clark in cooperation with *Science Service* and

representatives of the press, was unusually good, full telegraphic reports being printed throughout the country.

Dr. D. W. Morehouse, president of Drake University and director of its astronomical observatory, was chairman of the local committee. With the cooperation of the vice-chairman, Mr. J. W. Studebaker, superintendent of public schools, Mr. Henry Nollen, chairman of the special committee on reception and entertainment, Dr. Walter L. Bierring, chairman of the committee of finance and local membership, admirable arrangements were made for the meeting. They secured the active interest of the governor of the state, the mayor of the city and its leading citizens. Everything possible was done to add to the pleasure of scientific men from a distance. More than four hundred citizens became associate members of the association for the meeting, a record never hitherto approached, and the attendance at the special addresses and more popular lectures was numbered by the thousands.

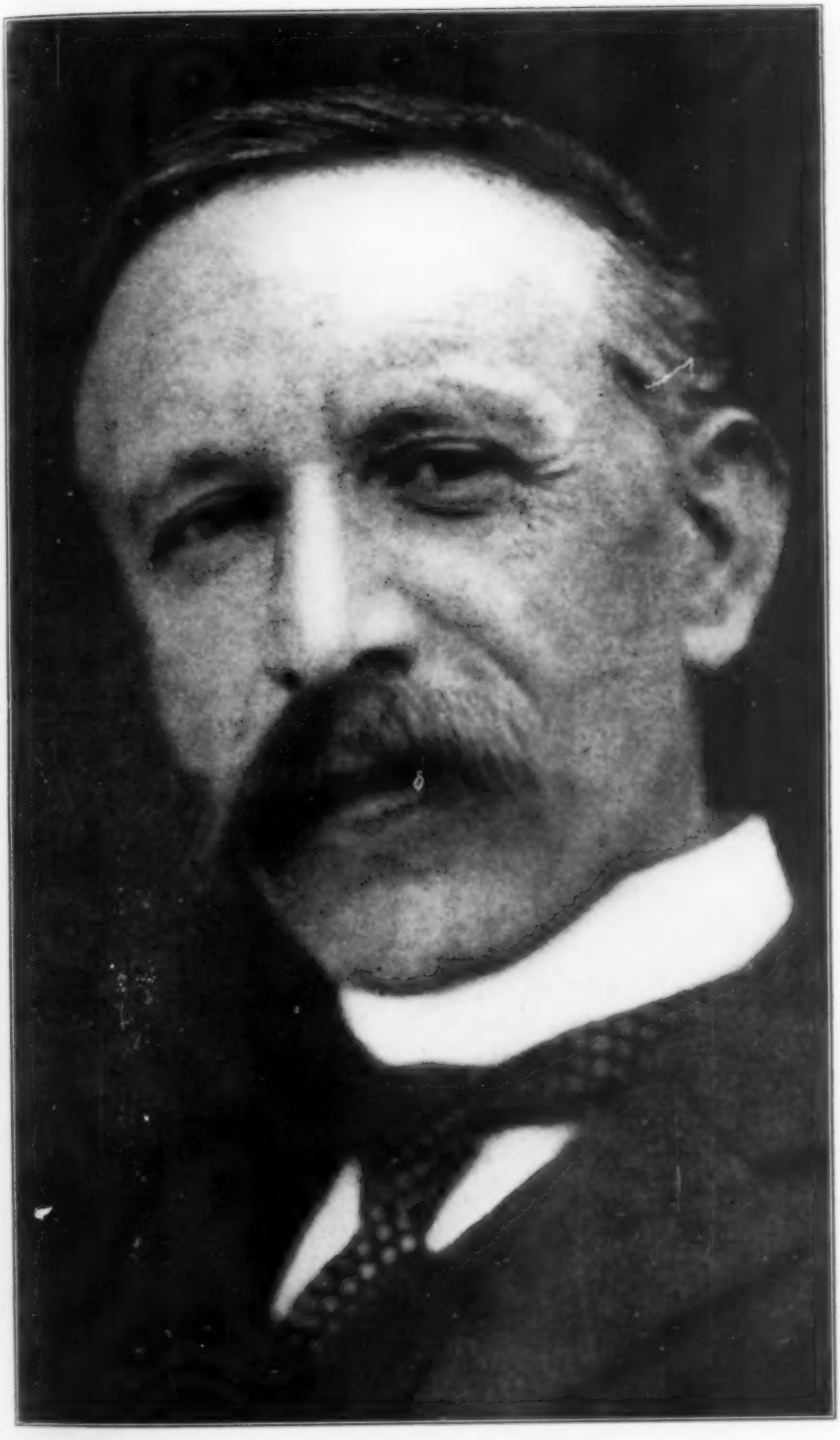
The association in turn had provided a program of general interest. The address of the retiring president, Dr. Henry F. Osborn, president of the American Museum of Natural History, at the opening session was on "The Discovery of Tertiary Man." On Sunday afternoon the president of the association, Dr. Robert A. Millikan, director of the Norman Bridge Laboratory of the California Institute of Technology at Pasadena, gave a lecture entitled "The Alleged Sins of Science." Dr. George H. Parker, of Harvard University, gave the Sigma Xi lecture on "Some Aspects of Human Biology," and Professor Irving Fisher, of Yale University, the Josiah Willard Gibbs Lecture on "The Application of Mathematics to the Social Sciences." There were in all twenty-two general and non-technical lectures, the speakers including Professor Edwin B. Frost, director of the Yerkes Observatory, Professor A. E. Kennelly, of Harvard University, and other distinguished men of science.

Dr. Thomas Hunt Morgan, director of the Kerckhoff Laboratories of Biological Sciences of the California Institute of Technology, until recently professor of experimental zoology at Columbia University, was elected president of the association to preside at the meeting to be held next year at Cleveland. The distinction of Dr. Morgan in scientific research has already been marked by his election to the presidency of the National Academy of Sciences, an office that has been held by only two other living men of science, Professor Michelson and Dr. Welch.

NOBEL PRIZES FOR PIONEERS IN THE FIELD OF VITAMIN RESEARCH

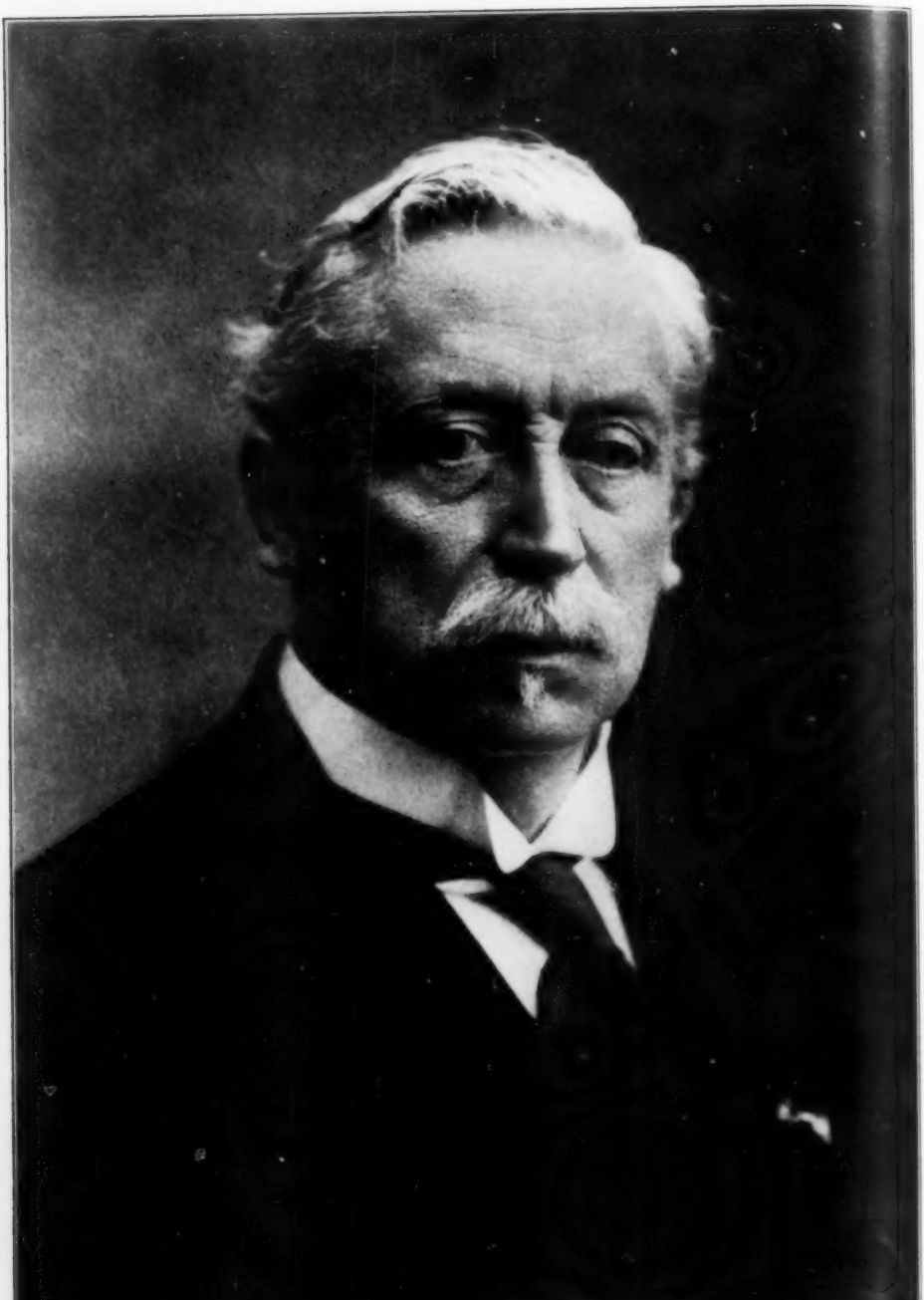
We owe the word "vitamine" to Casimir Funk, but when Funk published his most comprehensive account of this subject he was at pains to dedicate it to Christian Eijkman. The volume of research publications on the relation of vitamins to nutrition is now enormous, but whoever reviews its significant papers turns first to a single paper by F. Gowland Hopkins in the *Annalist* of 1906 and cites it and him as the first to recognize the existence and significance of these factors in nutrition. It is, then, peculiarly gratifying to workers in the field of vitamin research that these two pioneers have been honored by the award of the Nobel Prize in Medicine.

Students of the subject will recall that the beginnings of vitamin research had a multiple origin. The problem of beriberi antedated by some years the problem of vitamins, or "accessory factors" as Hopkins called them, in normal nutrition. Beginning with Takaki, in 1878, the dietary origin of beri-beri became progressively evident. Much of



FREDERICK GOWLAND HOPKINS

PROFESSOR OF BIOCHEMISTRY AT THE UNIVERSITY OF CAMBRIDGE



CHRISTIAN EIJKMAN

PROFESSOR OF HYGIENE AND LEGAL MEDICINE AT THE UNIVERSITY OF UTRECHT

the pioneer work on its etiology centered in Java. It was there that the Englishmen, Fraser and Stanton, made their classic contributions. It was in the Dutch Station in Java that Christian Eijkman entered the picture and in 1898 demonstrated that the disease could be actually produced in fowls by dietary measures. Human beri-beri is rarely uncomplicated, is usually a syndrome of symptoms due to multiple deficiencies. Human subjects therefore made difficult clean-cut relation between specific cause and specific effect. Eijkman's discovery made it possible to place the study on a scientific experimental basis. He gave us an experimental animal to work with and the prodigious strides since 1928 are perhaps due more to this one contribution than to any other single discovery. It is logical and fitting that two of his successors in the Java Station, Jansen and Donath, have been the first to isolate a crystalline anti-beri-beri substance of proven efficacy.

The contributions of Frederick Gowland Hopkins to prophylactic nutrition extend far beyond the field of vitamin research. The work of Osborne and Mendel in this country was directly stimulated by Hopkins' theories about the quality of proteins in diet. The use of white rats by Hopkins in his protein quality studies led him to postulate the existence of "accessory factor" in 1906 and to recognize the existence of such factors in milk. This discovery in turn was directly responsible for the use of "protein-free milk" by Osborne and Mendel in their studies of the significance of individual amino acids and ultimately to the separation of what we now call vitamins A and B. To vitamin research workers the Nobel Prize award to Hopkins for initiation of work in this field is singularly appropriate.

At the same time it is to be granted that the award might have been made to him on any one of a great variety of bases. His work on uric acid and its quantitative estimation, his discovery of tryptophane, his work on the significance of protein quality, his studies of the Bence-Jones protein, of xanthine oxidase, and in recent years his isolation of glutathione from muscle and his classic collaborations with Sir Walter Fletcher into the nature of biological oxidations; any one of these would have justified the recognition of Sir Frederick Hopkins as outstanding in the field of biochemistry.

The apportioning of recognition and responsibility for scientific achievement is far more difficult to-day than in earlier years. To-day contact between workers and laboratories is much more intimate. Secrecy and cloistered effort has been replaced by openness and group effort. Ultimate solution of almost any problem is almost inevitably to-day the resultant of a combination of brains and laboratories often widely separated geographically. It is rare, then, that in crowning success the lines of responsibility for leadership and inspiration lead so clearly and so directly to single men as in the present case. The world over there has been immediate and satisfied rejoicing that the Nobel Prize award has singled out Frederick Hopkins and Christian Eijkman.

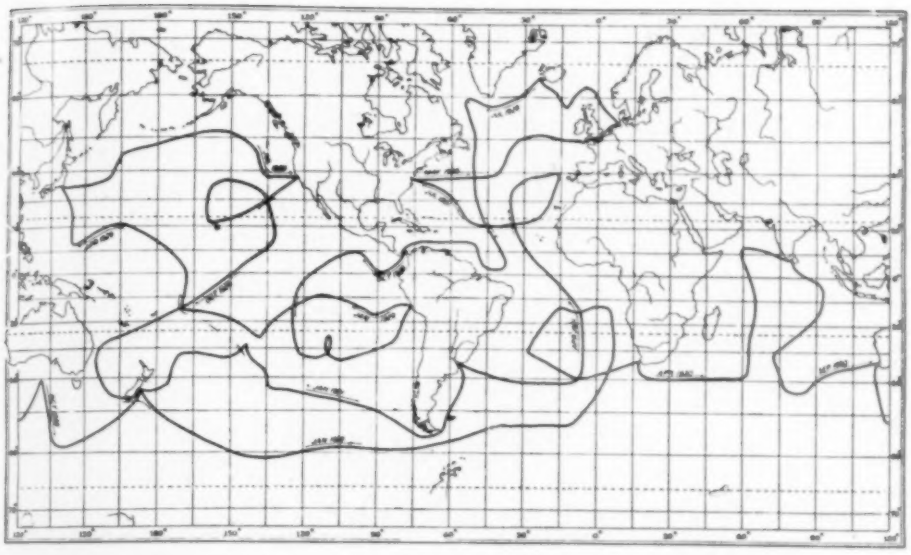
W. H. E.

THE LOSS OF THE CARNEGIE AND THE DEATH OF CAPTAIN AULT

THE destruction by explosion and fire of the non-magnetic yacht *Carnegie* and the tragic death of its commander, Captain James Percy Ault, in the harbor of Apia, Western Samoa, is a serious loss to science, not less so because the larger part of the wide-reaching program of the Carnegie Institution of Washington had been accomplished. An article by Captain Ault on the purpose and progress of the ocean survey under his charge was published in THE SCIENTIFIC

JAMES PERCY AULT

LATE COMMANDER OF THE "CARNEGIE"



TENTATIVE ROUTE FOR SEVENTH CRUISE OF THE "CARNEGIE"

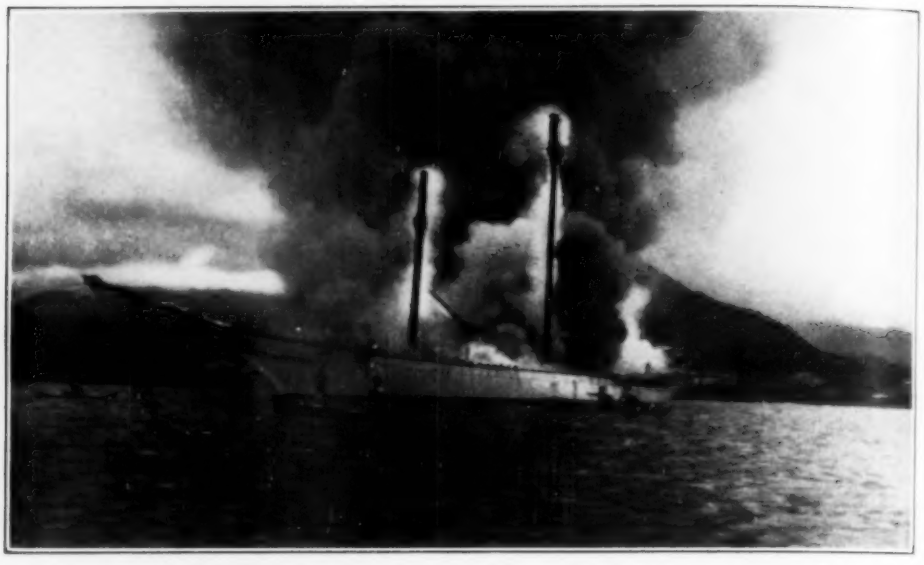
MONTHLY for February, 1928. Up to that time the *Galilee* had covered more than 73,000 miles during three cruises in the Pacific Ocean from 1905 to 1908, and the *Carnegie* more than 291,000 miles during six cruises in all oceans from 1909 to 1921.

Two months after the publication of this article the *Carnegie*, under the command of Captain Ault with eight scientific men and seventeen seamen, left Washington for a cruise of three years over the oceans of the world as shown on the accompanying map. The vessel, built twenty years before, had been completely overhauled and reconditioned. Laboratories had been added to provide for a broadened program of study which included several of the newer branches of oceanographic research. Four years had been spent in preparing for what was to have been the last cruise of the vessel under the Carnegie Institution, inasmuch as it was intended that future expeditions would be dispatched under other auspices.

A year and four months later a body of distinguished scientific men, headed by President Merriam, gathered on the *Carnegie*, at San Francisco, to greet Captain Ault and his staff and to felicitate them upon their progress. A program aboard the ship in celebration of the twenty-fifth anniversary of the founding of Carnegie Institution and of certain of its major departments of research, among them the department of terrestrial magnetism, under the supervision of which the *Carnegie* was designed, constructed and operated.

The yacht had put in at San Francisco for reconditioning preparatory to entering upon the last and longest stretch of the cruise. In conformity to program the vessel had encircled the North Atlantic, had passed through the Caribbean Sea and the Panama Canal, had cruised in the southeastern, central and northern regions of the Pacific, and had touched at many points in the Pacific including Easter Island, Peru, Tahiti, Guam, Samoa and Japan. Of the estimated 110,000 miles of the three-year cruise, 43,000 miles had been covered.

A wireless from Captain Ault on September 23 reported safe arrival at Hono-



DESTRUCTION OF THE "CARNEGIE"

lulu. A cable from Pago Pago, Samoa, on November 27 stated that the expedition was leaving that port. On the morning of November 28 the vessel anchored in the harbor of Apia, Western Samoa. All was well with ship and staff. Twenty-four hours later appeared the message which made known to the world that for the *Carnegie* and her commander the voyage had forever terminated.

In concluding an account of the last voyage of the *Carnegie* and an appreciation of Captain Ault, John A. Fleming, acting director of the department of terrestrial magnetism, and Frank F. Bunker, editor, of the Carnegie Institution of Washington, say:

"It is not often that a man's qualities of temperament and character fit him completely for the work he does. Perhaps it would be more correct to say that rarely does opportunity provide him with that work for which, by nature and training, he is best qualified. However that may be, those who knew Captain Ault intimately and worked with him are a unit in declaring that never was there a finer illustration of that accord betwen worker and work which brings inevitable and unquestioned success.

"Captain Ault had a rugged physique and a commanding presence. He possessed forcefulness, resourcefulness and the ability to make quick decisions. Gifted to an unusual degree with the qualities of leadership he was, withal, sympathetic, kindly and broadly tolerant. He was a gentleman of the finest type who quickly won the friendship, good will and cooperation of all. Moreover, he was skilled in navigation, abreast of general scientific thought, and an authority in his own field. Could there have been a combination of qualities more splendidly suited to a commander of the *Carnegie*?"